Electrochemical Industry

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CONTENTS.

INTERNATIONAL CONGRESSES AND SOCIETY MEETINGS.

In connection with the St. Louis World's Fair a greater number of international congresses will be held during September and October; of those which should be of special interest to our readers, the Electrical Congress promises to be of the greatest importance and it seems fortunate that the American Electrochemical Society has cast its lot with the Electrical Congress. Much good can come from a more intimate intercourse between electrochemists—who are, after all, primarily chemists and metallurgists—and the workers in other fields of electrical engineering. An excellent and elaborate programme has been arranged for the first American meeting of the Society of Chemical Industry, to be held in September in New York City, and for the following trip of members and guests through the country, taking in the two chemical congresses in St. Louis. Two of our national engineering societies have also arranged attractive trips through the country, viz., the American Institute of Electrical Engineers and the American Institute of Mining Engineers. Condensed programmes of the various meetings and excursions are printed on another page of this issue, while we will print detailed programmes in our next issue.

THE LEAD ACCUMULATOR AND THE OXYGEN-LIFT CELL.

This issue contains the conclusion of the able paper of Mr. M. U. Schoop on the theory of the oxygen-lift cell. The simple and ingenious method of studying the variations of weight of an electrode, suspended on a balance, during and after the passage of a current, at various discharge rates, enables the author to investigate the concentration changes developing in the pores of the plates during discharge, together with the resulting diffusion phenomena, and to determine the changes of the specific weight of the active materials, due to contraction or expansion. Mr. Schoop's paper contains the first published results of experiments enabling us to follow up more in detail the reactions in the Edison battery. His results are especially interesting in the light of our knowledge of the corresponding reactions in the lead accumulator. It is quite interesting to compare the behavior of the lead accumulator with that of the Edison battery and to explain the difference of their behavior by the difference of the chemical reactions.

During discharge of a lead cell, sulphuric acid is consumed at both plates, since both the lead peroxide and the spongy lead change to sulphate; an amount of acid is therefore removed from the electrolyte, proportional to the ampere-hours given out by the cell. During discharge of the Edison battery, the active nickel material is reduced from a higher state of oxidation to a lower one, while the active iron material is oxidized to a higher state of oxidation; the total amount of

KOH in the electrolyte remains constant. Since the equation of the reaction in the lead accumulator shows the participation of the electrolyte in the reaction producing the current, the principles of thermodynamics require that the electromotive force should depend on the concentration of the acid. On the other hand, since the equation of the reaction of the Edison battery does not contain the electrolyte at all, its electromotive force must be independent of the concentration of the KOH solution. Both these conclusions from the principles of thermodynamics have been confirmed experimentally. During discharge the concentration of the acid in the lead accumulator decreases, hence there must be a corresponding drop of the electromotive force. For the Edison battery we cannot make a parallel statement.

The place where any electrolytic reaction occurs is in the molecular layer at those places of anode and cathode where oxidation or reduction occur respectively. The active material of every storage battery has a certain measurable thickness, and during discharge the places of oxidation and reduction are moved from the outside layer of the plate to the inside. When the discharge has gone on for a certain time, the points of the electrodes at which the electrolytic reaction occurs is no longer in contact with the main quantity of electrolyte between anode and cathode, but with the electrolyte in the pores of the plate; and the electrolyte in the pores of the plate will differ from the outside main portion of the electrolyte and this difference will be the greater, the higher has been the discharge rate, since for a high discharge rate diffusion and convection currents have not sufficient time to destroy developing concentration changes. This fact has the following consequences for the lead accumulator and for the Edison battery. During discharge of the lead cell the concentration of the acid in the pores of both plates decreases more rapidly than that of the main portion of the electrolyte. During discharge of the Edison battery the concentration of the potassium hydroxide solution increases in the pores of one plate and decreases in the pores of the other plate, while the concentration of the main portion of electrolyte remains constant.

These facts are of consequence for the drop of the electromotive force. The electromotive force of a lead accumulator, when discharged at a high rate, will drop more rapidly than corresponds to the decrease of the concentration of the main portion of electrolyte between the plates; in other words, the higher the discharge rate, the greater the voltage drop. On the other hand, it is possible to show thermodynamically that the change of the electromotive force of the Edison battery, due to the local concentration changes, is of less practical importance; this is the reason why the Edison battery stands high discharge rates much better than the lead cell. Nevertheless, Mr. Schoop's experiments show that there is a measurable variation of electromotive force, due to local concentration changes in the pores of the plates. It is especially interesting to observe what happens when the current is interrupted after a discharge with a high rate. In the lead accumulator fresh acid passes into the pores and the electromotive force rises correspondingly. The same phenomenon is evident in Mr. Schoop's tests of the iron electrode of the Edison battery. On the other hand, this phenomenon is masked in the nickel electrode by other phenomena of far greater importance. Concerning the change of internal resistance we have already spoken in our last issue; here again the situation is quite different in the Edison battery from that in the lead cell.

While Mr. Schoop's experimental results fully confirm the conclusions of the theory concerning concentration changes in the Edison battery and their consequences, his results concerning expansion and contraction of the active masses represent something new which could not be predicted by the theory. All theoretical conclusions concerning concentration changes in the Edison battery are independent of the chemical nature of the active materials of the electrodes, i. e., the same concentration changes should take place with a KOH solution, whether we have a nickel-iron or a silver-cadmium cell, as long as it really is an oxygen-lift cell. Moreover, it should not matter whether the reaction at the nickel electrode is, for instance, the reduction from NiO_2 to Ni_2O_3, or from Ni_2O_3 to NiO or something else; a certain number of ampere-hours should always give a certain change of concentration. But the knowledge of the exact nature of the chemical reaction at the active materials becomes important in connection with their expansion and contraction. Here is a very promising field for experimental research, and when experiments supply us with the necessary data, we may hope to see the principles of modern physical chemistry applied to the explanation of all details of the behavior of the Edison battery with the same success as they have been applied in the case of the lead accumulator.

A UNIVERSAL LANGUAGE.

Prof. Wilhelm Ostwald is a man of most versatile genius. Everybody knows his important and inspiring pioneer work in electrochemistry and physical chemistry, his work as an original investigator, teacher and author. Then he has been interested in what he calls energetics and has endeavored to build up a new system of antimaterialistic metaphysics—essentially a glorification and idolization of energy. Recently he surprised his friends by his Letters of a Painter; and still more recently he delivered a lecture before a local section of the Association of German Engineers on the necessity of a universal international language, and this lecture was afterwards distributed in print at the annual meeting of the Bunsen Society. Prof. Ostwald requested the co-operation of the members of the Society in his endeavor to bring this scheme nearer to realization. The scheme may seem fantastical, but is fascinating, and it should be considered not in its relation to philology—in this respect we could not speak about it—but in its relation to international commerce for which it is possibly of similar importance as telegraphy, telephony and railroading. Manufacturers and merchants would probably gain most by its realization, but it is also of importance for scientists, since the scheme of a universal language is in intimate connection with that of uniform notation of scientific terms.

The idea of Prof. Ostwald is that everybody should learn two languages, the language of his nation and the universal language. He has been asked why we should not make English the universal language, and thinks this would not do for two reasons: Other nations might not be unselfish ("selbst-

los") enough to recognize English as the standard language and, then, English is not simple enough. An artificial language could be rendered much more simple. Prof. Ostwald refers to an occurrence at an international scientific congress. There were four professors who would have liked to talk with each other; one came from Germany, the others from Norway, Roumania and Belgium; all could read several modern languages, but could not speak them, but the latter three spoke "esperanto," an artificial language. They came along all right, while the German was out of the race. When he inquired of the others how long it had taken to learn "esperanto," he was told two or three weeks. Prof. Ostwald mentions this to prove that the scheme is feasible; it makes no difference to him whether the universal language shall be volapük or esperanto or something else; he leaves it to the philologists to work the language out and he leaves it to an international congress in which the different nations are represented by official delegates, to decide on the language. The idea may be phantastic and may never be realized, but it is certainly not ridiculous. It is capable of realization, and if our manufacturers shall continue to extend their export trade, they will surely prefer to deal with their foreign customers in a simple artificial language than in the various languages of the countries to which they export their goods.

The comprehensive scheme of Prof. Ostwald intends to give to all the people an international language such as, in the realm of their own science, chemists already have in chemical notation. N means the same element all over the world, whether we speak of nitrogen or the Germans of stickstoff, or the French of azote. A chemical equation confers the same information to everybody, although if expressed in words, it sounds quite different in different languages. The difficulties, however, which are likely to arise in the comprehensive scheme of an international language for everyday life, are already indicated in our special case by the tenacity with which some chemical scientists insist on $H = 1$, against $O = 16$. Nevertheless, chemical notation on the basis of molecular theory is a nearly perfect example of the advantages which we would get by a universal language. It is regretable that there is much less uniformity in the notation of physical chemistry and electrochemistry. Thus, the list, proposed by the Bunsen Society at the last International Congress for Applied Chemistry and published in our issue of last November, contains some Germanisms, like W for resistance, which will never find universal approval. With his abundance of energy—or we should rather say thermodynamically "free energy"—Prof. Ostwald could do more than anybody else to bring about uniformity of notation in these special fields.

We may use this opportunity to say a few words concerning our systems of units and measures. They represent those quantities which are most important to engineers in all their work, and the trouble is that the different nations have not only different names for the same physical quantity, but that the quantitative values of the unit itself are different. Lord Kelvin said once: "I look upon our English system as a wickedly brain-destroying piece of bondage under which we suffer." These words are as true as when they were spoken in Philadelphia twenty years ago, though much has been done in the meanwhile towards uniformity, so that we may even

hope to see the day when the metric system will be in universal use. A good part of the general progress has been due to the rapid development of electrical engineering. With units based on the centimeter-gram-second system electrical engineers were naturally not handicapped from the start with the burden of arbitrary relations, reigning supreme in other departments of engineering.

In the matter of units the development of electrical engineering has thus exerted a beneficial influence on engineering in general. Nevertheless, we notice even here some curious facts in special instances. Thus, as the unit of electric resistance we have universally the ohm. But here the same name covers various quantities. We have the "international" ohm, as defined in Chicago in 1893 as the resistance of a column of mercury of uniform cross-section, at 0° C., 106.3 cm. long and weighing 14.4521 grams. We have had the "legal" ohm for which the length of mercury is 106 cm., the other figures being the same. We have the "true" ohm, being 10^9 electromagnetic c. g. s. units. Thus the value of the ohm is only a matter of definition, and in engineering practice it does not cut any figure which ohm we mean. Practical engineers would not stand for any uncertainty that would matter in practice. The subject of units will come up again for consideration at the International Electrical Congress in St. Louis, but the national society of electrical engineers in Germany has already announced that it does not like to render its aid to the proposed changes of units, and will therefore not send delegates to the congress. We have mentioned this instance to show the difficulties in the way of international agreements in cases where the necessity of absolute uniformity is not denied by anybody. In the light of this tiresome experience, Prof. Ostwald's scheme of reaching an international agreement on the subject of a universal language might seem absolutely hopeless. Yet the latter subject should appeal to manufacturers and business men. A successful business man knows a good thing when he see it, and he knows how to accomplish something if he wants it. Any progress that should be made in the direction of a universal language would be a splendid subject lesson to scientists.

SOLUBILITY OF GOLD.

In the operation of the cyanide process it has long been recognized that for the solution of gold in potassium cyanide solutions a supply of atmospheric oxygen is very important. In those electrolytic processes in which the electric current is used for dissolving the gold, it is probable that the action of the current is essentially to supply the oxygen required for solution. In this connection it is interesting to note the results obtained by Dr. V. Lenher, as published on another page of this issue. He shows that gold is not only attacked by halogens, but is also readily attacked in a large number of reactions in which oxygen is produced. Anodic oxygen, for instance, is very active. A plate of metallic gold, used as anode, dissolves in an electrolyte of sulphuric acid or a mixture of nitric and sulphuric acid. But it is not necessary that the oxygen is produced by the electric current; on the other hand, it appears that it is necessary for the oxygen to be produced in the mixture and that ordinary oxygen gas, where conducted into sulphuric acid in which gold leaf is suspended, will not cause the gold to dissolve.

INTERNATIONAL CONGRESSES AND SOCIETY MEETINGS.

In connection with the St. Louis World's Fair a number of International Congresses will be held.

The *International Electrical Congress* will convene in St. Louis on Monday, September 12, 9:30 a. m. The opening ceremonies will be held in the music hall of the Coliseum at Olive and Thirteenth Streets. The meetings of the eight sections follow, commencing at 11:00 o'clock a. m. in the section hall on the second floor of the Coliseum, the sections adjourning on Monday, at 1:30 p. m. On Tuesday, Thursday and Friday the sections will meet on the second floor of the Coliseum at 9:00 o'clock a. m., and will adjourn not later than 1:00 p. m. Programmes of the papers to be presented were published on pages 214 and 258 of our June and July issues.

The *Congress for Inorganic and Organic Chemistry* will be held on Wednesday, September 21, the *Congress for Technical, Physical and Physiological Chemistry* on Thursday, September 22.

The *International Engineering Congress*, arranged by the American Society of Civil Engineers, holds its sessions in St. Louis from October 3 to 8.

The *American Electrochemical Society* will hold its meeting at St. Louis on the 13th, 15th and 16th of September. On the 13th and 15th joint sessions will be held with section C (Electrochemistry) of the Electrical Congress and on the 16th a joint session will be held with the Bunsen and Faraday Societies. Sessions will be held only in the morning. No session is being arranged for the 14th, as it is thought by officers of section C that if an independent meeting is set for the 16th, rather than the 14th, the section may be through its work by that time and be able to attend the session of the Society.

The annual convention of the *American Institute of Electrical Engineers* will be opened on Wednesday, September 14, at 10:00 a. m. at Festival Hall and the president of the Institute, Mr. Bion J. Arnold, will deliver the annual address. Immediately afterwards a topical discussion will follow between the Institution of Electrical Engineers of Great Britain and the American Institute of Electrical Engineers, the subject of which will be announced later. Arrangements are being made for holding a closing meeting of the International Congress.

At the invitation of the American Institute of Electrical Engineers a large number of members of the (British) Institution of Electrical Engineers, being accompanied by their ladies, are expected to arrive in this country by the White Star Steamship "Republic," reaching Boston on the 22d. They will travel from Boston to New York. After that a special circular tour for foreign delegates, visiting electrical engineers and guests has been organized under the auspices of the American Institute of Electrical Engineers. This tour begins on September 6, and covers visits to Schenectady, Montreal, Niagara Falls, Chicago, St. Louis, where the party stays from September 11 to September 17; after this, Pittsburg, Washington, Philadelphia and New York.

The eighty-seventh meeting of the *American Institute of Mining Engineers* will be held in the Lake Superior iron and copper regions, beginning at Duluth, Minn., on Wednesday, September 14. An excursion has been arranged in connection with this meeting, starting on September 10th from Buffalo, with visits to Cleveland, Detroit, Mackinac Island, Sault Ste. Marie, Duluth, where the party stays from the 13th to the 18th, a trip to the Masebi range being sandwiched in for the 16th and 17th. Duluth is left on September 18 for Houghton, Ispheming, Mich., and Chicago, where the party arrives on the 22d. Those who desire to visit the St. Louis Exposition will then proceed to St. Louis, where a session will probably be held on Monday, September 26, for the presentation of papers, etc., aiding in the study of the mining and metallurgical

features of the Exposition. Members may then take part in the International Engineering Congress from October 3 to 8.

The *Society of Chemical Industry* will hold its first American meeting in New York City from September 7th to 11th, for which a most elaborate programme has been arranged, a general outline of which was given in our April issue, page 148, which will be fully carried out, all arrangements having been completed. Over eighty (sixty-seven gentlemen and fourteen ladies) from abroad have already signified their intention of accepting the invitation of the New York Section of the Society of Chemical Industry, and this list is being added to from time to time, and it is hoped that the final number will be not less than 100. The expense of entertaining members from abroad while in New York, and for the cost of their transportation and sleeping accommodations on the round trip through the country is covered by subscription by the New York Section. On the round trip the following places will be visited: Philadelphia, Washington, Pittsburg, St. Louis, Chicago, Detroit, Buffalo, Niagara Falls, Boston and back to New York. For the visits of these places, a most elaborate programme has been arranged. The members participating in the trip will attend the congresses for Inorganic and Organic Chemistry, and for Technical, Physical and Physiological Chemistry in St. Louis on September 21 and 22.

More detailed programmes of the various meetings and congresses will be published in our next issue.

GERMAN CHEMICAL INDUSTRY.

The recent annual meeting of the Association of German Chemists, held at Mannheim, led to the publication of interesting statistical information as to chemical industries in Germany. In 1897 the total value of the more important manufactured products of Germany was about $2,120,000,000. At the top of the list stood the products of the iron and mining industry, with a value of nearly $840,000,000. Next came textile manufactures, whose value in round numbers was $650,000,000. This was followed by chemical manufactures with a total value of about $226,000,000. Including with chemical products proper those of the rubber, gutta-percha, celluloid, paper and wood pulp factories, the total output in 1897 was approximately $256,000,000. In 1903 the total production of the German chemical factories, using the term in its narrower sense, was estimated at $321,000,000. This industry has shown a marked tendency in Germany to concentrate in certain localities without special reference to the sources of raw material. The most important centers are the Barmen-Elberfeld region, Frankfort on the Main and its environs, and the Mannheim-Ludwigshafen district, which includes the two towns named, separated only by the Rhine. In the variety of its products and the magnitude of some of its undertakings, the last-named district leads all the others. In it are located at present seventy-three factories for the manufacture of chemicals. Of these, thirty-seven are to be reckoned as important, the remainder being small. Eleven of the thirty-seven are located at Ludwigshafen and twenty-six are at Mannheim. The seventy-three factories employ a total of 15,325 workmen; the total population in the two cities dependent upon this branch of manufacturing is not far from 55,000. As to character of products, the factories group themselves somewhat as follows. First, factories for the manufacture of inorganic products, acids, salts, fertilizers, etc. (thirteen factories). Second, factories for the manufacture of coal-tar products, oils, fats, varnishes, etc. (thirteen factories); among these is included the Badische Anilin and Soda Fabrik, the largest of its kind in the world, employing now 7,800 workmen, besides about 1,000 chemists and office employees. Third, rubber, celluloid and wood pulp factories. This group includes the largest wood pulp factory and the largest celluloid factory of Germany, the two factories employing somewhat more than 3,000 workmen. The value of the present yearly output of these two cities is estimated at $32,000,000.

POWER TRANSMISSION FOR ELECTROCHEMICAL WORKS.

BY LOUIS BELL, PH. D.

The rise of electrochemical industry has produced a new set of problems in the generation and transmission of power. The first necessity in electrochemical works is an abundant, and, above all things, cheap supply of electrical energy, for in no other class of manufacture is power so large a proportion of the expense account. A machine shop may pay a fairly high price for its power and still, through the incidental reduction of losses and improvement in output that follows the introduction of motors, be able actually to reduce the power charge against its product to a very modest figure. In electrolytic reduction works, on the other hand, the process itself demands electrical energy in amount which bears a predeterminable relation to the output, and the final economic result hinges mainly, if the reactions concerned are reasonably clean, on the cost of this energy.

The power supply must also be regulable to an extent which is unusual in other classes of manufacture. In some processes accurately uniform voltage is of the first importance, in others a voltage which may be held steady over a very wide range of values is necessary, and in still others commercial success depends upon absolute continuity of the power supply. Each process has its own special requirements, which must be met under penalty, not of delay or inconvenience, but of failure and serious loss. Hence, the demands of electrochemical works on the generating plant are necessarily severe, and comparatively few stations can meet them without special precautions.

Broadly, it is, therefore, best for electrochemical industries to own and operate their own generating plants. The next best thing is to locate near an ample source of power already developed. As a commercial proposition, current for electrochemical uses is often a somewhat undesirable load for a supply station, in view, first, of the sometimes severe requirements, and, second, of the fact that motors and lights at ordinary current prices constitute a more profitable load. There are, however, two cases in which good terms can be made between a supply company and electrochemical works. The first is where the electrical development, as at Niagara, is on so enormous a scale that the market prices are in a measure controlled by a relatively moderate, although absolutely very great demand, and the size of the plant renders it easy to take care of even the severest demands. Instances of this kind are obviously not common. The second case is where the electrochemical demand for power is not necessarily continuous throughout a long working day. The salable energy of a plant is limited by the conditions of maximum demand, and since in a hydraulic installation the operating cost varies but little with the output, energy which can be added to the output sold without increasing the peak of the load can well be sold at a moderate figure.

For example, a chemical plant that, by reason of its process, could undertake to demand no power between 3 or 4 p. m. and midnight, could make extremely good terms with a great many hydraulic plants, and would form a welcome addition to the load. If electrochemical works can be operated discontinuously at all they can be worked at odd hours more readily than any ordinary manufacturing establishments. This phase of the situation is well worth the attention of one who is contemplating the establishment of an electrochemical process.

There are not a few power plants which have sold their output up to the limit of their generating capacity at the peak of the load, and which would find it to their interest to sell their power available except at the peak, at a moderate figure, rather than to provide a supplementary steam plant or heavy storage battery to take care of an increased peak.

So much for the general economic conditions. As to the concrete question of cost of electrical energy it must be considered under two heads, supply from a separate corporation and supply from a plant of one's own. The market price of power varies prodigiously from place to place. Aside from Niagara, the ruling prices for cheap electrical energy for motors range from $15 per horse-power-year up, for ten to twelve hours per day—roughly, half a cent per electrical horse-power-hour—two thirds of a cent per kilowatt-hour. This figure is seldom bettered, in fact rarely reached, and can be made by very few plants unless at a loss. The number of hydraulic stations for general power supply able to make such quotations, save for power off the peak period is, and always will be, very limited. Anything under a cent per kilowatt-hour is very cheap power indeed, even to large consumers. As already intimated, the best chance to get these low figures in electrochemical work is to make terms for power at times of otherwise light load, when the character of the process permits. Under any ordinary circumstances, when energy can be had at or below one cent per kilowatt-hour, it is cheaper for the average large consumer to buy it than to produce it in a plant of his own.

In the case of large electrochemical works, however, it undoubtedly pays to make a very thorough examination of locations in which good transportation facilities are joined with the possibility of getting within reach of an available water-power for development. The engineer is very often asked as to the distance to which it is economically advisable to transmit electrical power. While the question cannot be answered off hand, experience has shown that up to twenty or twenty-five miles the total cost of transmission is not at all serious. Beyond this one should go into details rather cautiously, although, of course, there are many longer transmissions which have proved to be economical, although not with a market requiring very low prices.

Within moderate distances the critical point of economy is the cost of developing the hydraulic power. This varies enormously, according to local conditions. . In any region where electrochemical work is likely to be carried on hydraulic rights have to be purchased at prices varying from, say, $5 to $25 per horse-power available throughout the year. Then comes the work of development, building dam and canal, blasting and dredging, building roads and retaining walls and power house and setting wheels. The total is most uncertain—almost anything from $25 or so per horse-power to $100 or more. The latter figure would be too large for serious consideration in connection with electrochemical work, and the smaller requires a rare combination of good fortune and low prices. As a rule, the hydraulic rights and development form together rather the larger half of the total cost of getting a power transmission under way. Of late years the costs of electrical machinery have fallen considerably, while the hydraulic construction costs have risen a little.

The line itself, owing to the present use of high voltages, has ceased to be a formidable factor in most transmissions. Ten thousand volts is about the lowest electrical pressure in vogue, and two or three times that voltage is common. At the usual line loss of 5 to 10 per cent the cost of the conducting wires can generally be kept down to, say, $5, and the total line cost to below $10 per kilowatt. Generators, and raising and reducing transformers are subject to considerable variation of cost with the speed and size of the first-named and the voltage and size of the others. Large output and high speed are conditions favorable to low cost. At the present time very excellent generators are made to deliver directly 10,000 to 12,000 volts and for transmission plant of moderate capacity at the shorter distance, say, up to a dozen miles, it is often cheaper to use these than a combination of low voltage generator and raising transformer. Roughly, the generator and transformer costs all together commonly run from $15 to $25 per kilowatt capacity of plant, reaching the lower limit only in large work under very favorable conditions.

Lumping all these various items of cost one may say in general that an electric power transmission plant from water

power, over a moderate distance, such as has been presupposed, is likely to cost from $60 to $100 per kilowatt capacity delivered on the low-tension side of the reducing transformers. Against this must be charged suitable interest depreciation and taxes, together with some general expense and the operating charges. A good deal of fog surrounds the matter of the fixed charges. Published costs of power generally are based on general and operating expenses only, but there is no good to be gained by deceiving one's self as to the final costs.

Private plants, such as are here being considered, probably fare better in the matter of depreciation and maintenance than most plants for general distribution of power. In the first place they have a relatively small amount of circuits to maintain, and they also suffer less acutely from depreciation due to change in the art, a serious item in public supply stations. The latter may be from time to time forced by competition or the current requirements of public service to make extensive changes in equipment at large cost. A private plant is installed to furnish electrical energy for a certain well-defined purpose, and as a rule the character of the demand will remain uniform, however the amount may increase.

No change can in the nature of things materially increase the efficiencies of generators, transformers and line, so that the depreciation to be dealt with is almost entirely physical, and modern apparatus enables one to make a good showing in this respect. Not to go too far into details, the average hydraulic electrical transmission plant is likely to find its total expense about equally divided between fixed and general charges, on the one hand, and operating expenses on the other.

As a matter of experience, this total is likely to amount to between 15 and 20 per cent of the total cost of the plant. Anything less than the former figure is a remarkably favorable performance. It is more likely to be reached in a large simple transmission, such as electrochemical works require, than in a more general distribution, particularly when the demand for power is such as to utilize the plant steadily for a large proportion of its capacity.

With this as a basis one may fairly reckon that the cost of power delivered in plants of the kind considered will be likely to be between $10 and $20 per kilowatt-year for twenty-four-hour power.

The former figure would be very exceptionally low, the latter rather high. Now, from this reckoning it plainly appears that the prices commonly charged by public supply companies working from cheap water power, are, upon the whole, very moderate, considering the risks assumed, and the difficulty of selling anywhere nearly up to the full capacity of the plant.

Fixed charges and attendance go right along day by day, irrespective of load, and a plant half utilized becomes a serious burden at times.

The special electrical apparatus required by electrochemical works to deliver particular kinds of output, such as low-voltage transformers, regulating apparatus with a wide range, and motor generators or rotary converters for delivering direct current, have been excluded from this discussion, as they really form part of the mechanism of utilization rather than transmission, and must be provided whether the electrical energy is purchased as such, or generated. Each industry has its own difficulties in this particular, and no general conclusions can be safely drawn.

The main thing is to come to a broad understanding of the cost of the energy which is the staple material of all electrochemical processes, and of the nature of the items which make up that cost. Small electrochemical works, demanding a maximum output of only a few hundred kilowatts can commonly make better terms with an established source of supply than they can make on their own account, unless an extremely favorable location near water power can be secured. Plants demanding considerably larger amounts of power can often generate it to advantage. In either case it is a case for careful engineering and a very close study of local conditions, which in the last resort determine the economy of power production.
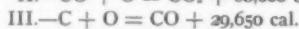

REDUCTION OF METALS.

By Oscar Nagel, Ph. D.

At the last meeting of the American Electrochemical Society some statements were made regarding the reduction of metals, especially of zinc, that were not quite correct (ELECTROCHEMICAL INDUSTRY, May, p. 185 to 187).

The assumption of carbon vapor in the reduction process is a hypothesis that shows no advantage and lacks every foundation. The mentioning of reduction by means of carbon monoxide is also not very accurate.

The reduction of metals is based in general on the following equations (G. Bodlaender, *Zeitschrift f. Electrochemie*, VIII., 44).

$$\text{I.—}C + 2O = CO_2 + 97,650 \text{ cal.}$$
$$\text{II.—}CO + O = CO_2 + 68,000 \text{ cal.}$$
$$\text{III.—}C + O = CO + 29,650 \text{ cal.}$$

Since the heat of formation or heat of reduction in I. is larger than in II. and that in II. again larger than in III., it would seem as though for substances which are reducible only with great difficulty, equation I., and for easy reducible substances equation III. would be the correct expression. But just the opposite is the case. III. is the correct expression for substances reducible with great difficulty, like zinc, sodium, calcium-carbide, carborundum, phosphorus, manganese, and silica, II. for relatively easily reducible materials like iron, and I. for very easily reducible substances, like silver, copper and lead.

It is, therefore, apparent that the sequence of the free energies of reduction is just contrary to the sequuence of the heats of reduction.

It is well known that in the reduction of zinc the quantity of free energy has to decrease. At absolute zero the energy of formation of zinc oxide is about three times as large as the energy of carbon monoxide.

Therefore—as the reduction is really taking place at a certain temperature—the proportion of these energies is undergoing a change with the changing temperature. At 1125° C. the energy of formation of zinc oxide is equal to the energy of carbon monoxide. This is the reducing temperature of zinc.

The reduction of zinc oxide by means of carbon monoxide at 1000° C. stops with a content of 0.1 per cent carbon dioxide in the gases and at 1500° C. with a content of 0.76 per cent carbon dioxide.

The reduction of zinc oxide, exclusively by means of carbon monoxide, would therefore require a temperature not in reach of our present methods.

Conclusions:

(I.) Formula II. does not play any part in the present method of zinc reduction.

(II.) The assumption of carbon vapor is an unnecessary hypothesis.

UNION ENGINEERING BUILDING.—The committee of the three national engineering societies and of the Engineers' Club has made the selection of architects for the new buildings. The successful competitor for the Union Engineering Building is Mr. Herbert D. Hale, of Boston, with Mr. Henry G. Morse, of New York, as associate architect. The successful competitors for the Engineers' Club are Whitfield & King, of New York. The United Engineering Building will occupy 125 ft. front by 100 ft. on West Thirty-ninth Street, while the Engineers' Club, with a frontage of 50 ft. and a depth of 100 ft., will face on Bryant Park and the new Public Library. The club building will be 11½ stories high, with the usual accommodations of a club and some sixty or seventy bedrooms for members.

THE PIONEER ELECTROLYTIC COPPER REFINERY OF THE UNITED STATES.

Copper refining is that field of metallurgy in which electrochemical methods have attained the greatest industrial importance, and it is in the United States that electrolytic copper refining has undergone the most important development. This is indicated by the fact that more than 85 per cent of the copper electrolytically refined in the world, is refined in the United States. There are only ten electrolytic refineries in this country, but all of them have a large output, and the total output of these ten refineries is about 280,000 tons per year. Under these circumstances it is, perhaps, surprising that the oldest American refinery is not older than about twenty-four years, somewhat younger than the electric incandescent lamp. This is not incidental. The development of electric lighting

prise and energy of the Balbach Works in Newark, who were the first to put electrolytic copper refining on a thoroughly satisfactory and commercial basis in the United States.

While in 1879 an experimental plant for electrolytically refining copper was operated for a short time at Phœnixville, Pa., yet the first commercial refinery in America was built early in the eighties by Messrs. Balbach & Sons at Newark, N. J. Mr. Edward Balbach, Sr., himself an excellent chemical engineer, and his distinguished son, Mr. Edward Balbach, Jr., who is now the president of the Balbach Smelting and Refining Co., had the courage to undertake this pioneer work; they placed the development of the process into the hands of Mr. F. A. Thum, a chemist and metallurgist from Germany, who worked out all the details of the process with such success that only very small minor changes became necessary
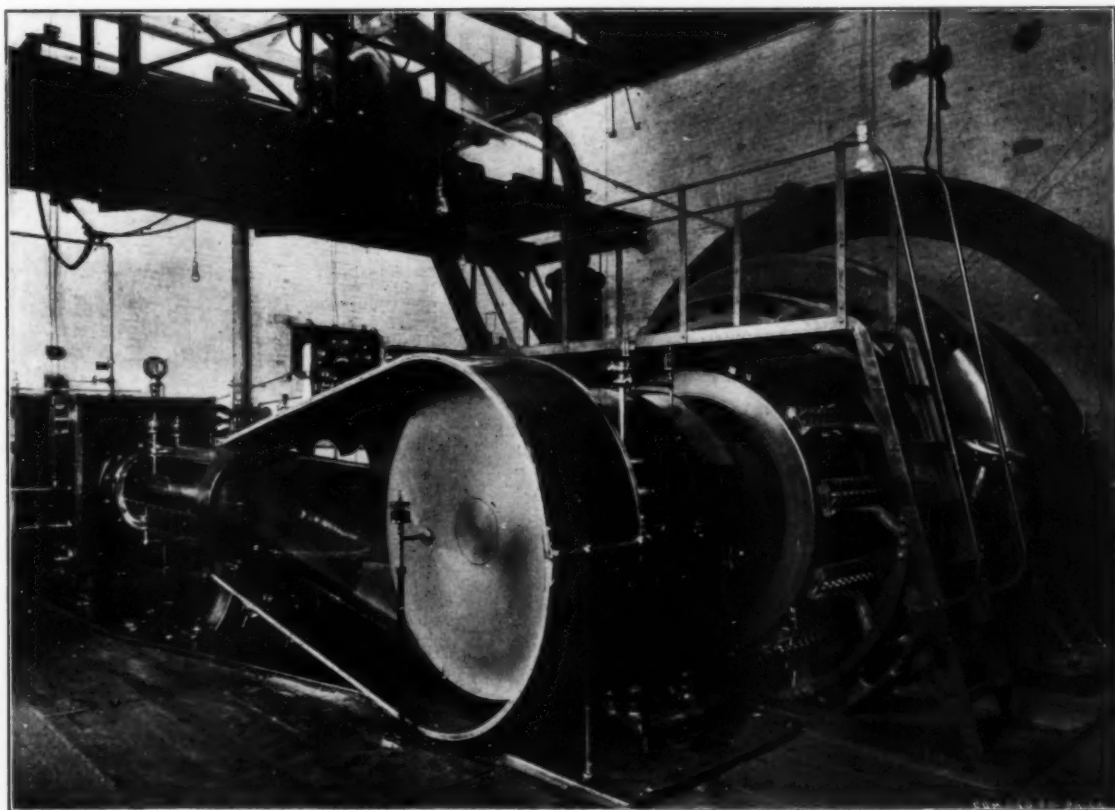

FIG. 1.—POWER PLANT OF THE BALBACH SMELTING AND REFINING COMPANY.

created a demand for pure copper, while the development of dynamo-electric machinery going on in connection with the erection of central stations, turned attention to electrical means for refining copper.

As a laboratory experiment, electrolytic copper refining is perhaps the simplest electrolytic reaction which can be imagined. On the other hand, this example shows very clearly the enormous difference between an experiment carried out on a test-tube scale, and the industrial proposition of carrying out a process with profit on a large scale. In laboratory experiments one often endeavors to get a high ampere-hour efficiency and watt-hour efficiency, and is satisfied if one obtains the same. In industrial operation it is the financial efficiency which should be made a maximum. Considered as a financial proposition, copper refining becomes a very complicated problem, as is evident from the recent paper of Mr. L. Addicks (Electrochemical Industry, May, 1904, page 180). Under these circumstances, the highest credit is due to the enter-

afterwards. The preliminary experimental researches were so successful that the Balbach Company decided to erect an electrolytic refinery on a large scale; this was completed in 1883, and since that time Mr. F. A. Thum has filled the position as superintendent of the plant, designed by him, up to to-day.

While at that time, there was already, among other smaller electrolytic refineries, that of Werner Siemens at Oker in the Hartz Mountains in Germany, yet they were tightly closed to any outsiders and absolute secrecy was kept concerning process and apparatus. It thus became necessary for Messrs. Balbach and Thum to work out independently all the details of their new plant. At the end of 1883 the Balbach Works produced from two to three tons of electrolytic copper per day, and the apparatus used at that time had been so well designed by Mr. Thum that, as was already mentioned, only some minor charges were made when the plant was enlarged as soon as the original output became inadequate. In fact,

the first electrolytic room installed by the company is still used to-day, and there are in it quite a number of tanks which have served their purpose successfully since the starting of the plant in 1883 and there is no essential difference between the original equipment and the present one, though the amperes employed have been increased from 1800 to 4500. The only change which has been made in the construction of the newer tanks is to make them a few inches higher in order to guard against short circuits, due to accumulation of the slimes at the bottom. All the principal arrangements have remained unchanged, although the capacity of the works has been considerably increased. The present output is about 45 tons per day.

The power plant which supplies current for the copper refinery contains three generators, the oldest of 120 kw. capacity is a Hochhausen machine, while two more recent machines, one of 100 kw. and one of 280 kw., were built by the Crocker-Wheeler Co. Fig. 1 shows a portion of the power plant of the copper refinery. The cross-compound Corliss condensing engines made by the Hewes & Phillips Co. are directly connected to the 280-kw. Crocker-Wheeler generator, which is mostly loaded with 300 kw., furnishing 4300 amperes at

The various tanks are connected in series. In two side-adjoining tanks the cathodes of one tank are connected to the anodes of the other tank, thus accomplishing a series connection of the two tanks. Flat copper pieces used as supports form connectors and light covers protect the connections against the corrosive influence of the solution in case any electrolyte is spilled when the plates are removed from the tanks.

All the tanks are on the same level. To provide for the necessary circulation of the electrolyte, each tank has its special outflow pipe and feeder pipe. If the outflow pipe is in one corner of the tank, the feeder pipe is provided in the corner diagonally opposite. Through the outflow pipe, the electrolyte flows off to launders placed below the boards on the floor on which the men stand in Fig. 3. The electrolyte is returned to the tanks from overhead launders through the vertical pipes shown in the same figure. Each of these pipes feeds four tanks, and for this purpose ends just above the point where the four tanks join together, and at its end the pipe then branches off into four pipes, which feed the solution into the four tanks.

All the tanks are in operation during the night, while during the day a certain number of tanks are regularly cut out of circuit and cleaned up. The treatment of the slimes which contain silver and gold will be described below. To prevent the solution from getting foul, a portion of the electrolyte is daily withdrawn from the tanks and fresh electrolyte is fed in. From the withdrawn electrolyte, the sulphates of copper and nickel are crystalized out one after the other, and the mother liquor is, according to its impurities, either put into use again, or is boiled down in cast iron vessels until the sulphates fall out as anhydrides which are dissolved in water and separated. The final sulphuric acid is very impure, and is sold to fertilizing works.
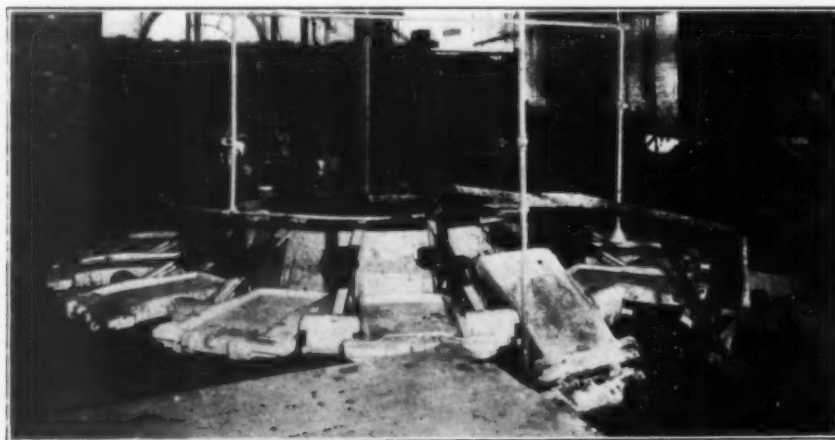

FIG. 2.—APPARATUS FOR CASTING COPPER ANODES.

about 70 volts. Upon the gallery in the background of the cut is shown a dynamo, belt-driven by the large engine below; it furnishes current at 125 volts for lighting and motor driving about the works. For the electrolytic winning of silver a separate Crocker-Wheeler generator is installed which gives 1800 amperes at 35 volts.

Copper Refinery.

There are in the whole, in the copper-refining rooms 440 electrolyzing tanks for depositing copper. Each tank contains 20 to 22 anodes and 20 to 22 cathodes, the plates being connected in multiple. The anodes, which are cast, as will be described below, have a size of 36 x 24 x 1¼ inches, and weigh from 300 to 400 pounds. The cathodes are thin electroplated sheets of copper of a size 36 x 24 inches. The current density used is 16 to 17 amperes per square foot, and the temperature of the electrolyte is maintained at about 50° to 60° C. (generally about 50° C.). The electrolyte is the standard copper sulphate solution, containing free sulphuric acid.

The tanks are arranged as shown in Fig. 3, giving a general view of the main copper refining room. As will be seen from this figure, the tanks are arranged in groups, each group consisting of two rows of tanks, so that always two tanks are placed side by side. All cathodes of the tanks in the left row are in the same plane as the anodes of the adjoining tanks in the right row, and vice versa. All the cathodes in the tanks are connected in multiple and so are the anodes.

The method of casting the copper anodes is shown in Fig. 2. It is essentially a combination of Walker's standard casting apparatus with a special anode tilting mould of Mr. F. A. Thum. There are fourteen moulds arranged in a circle upon a turntable, which is revolved step by step, so that one mould after the other is filled with molten copper from the furnace shown in the back of the illustration. The moulds are normally in a horizontal position, and while the turntable with the moulds is revolved, the molten copper in the moulds gradually cools off. If necessary, water is sprinkled from above to accelerate the cooling off. When the mould reaches the point diametrically opposite to the point where the molten copper was poured into it a catch is released and the mould is tilted out of its horizontal position, as is clearly shown at the right hand in the front of Fig. 2. Mr. Thum's mould (U. S. patent 733,095, of July 7, 1903) is so constructed as to facilitate the removal of the cast anodes from the mould. For this purpose that part of the rim which forms the end face of the upper or suspension end of the anode (having the two lugs) is hinged to the main part of the mould. When the mould is tilted out of its horizontal position, the hinged part of the rim is swung away automatically from the bottom of the cavity of the mould and the anode-casting slides longitudinally out of the mould without meeting any obstruction. The anode drops on a moving platform, immersed in water, that carries it to a carriage which transports the anodes to the refining room.
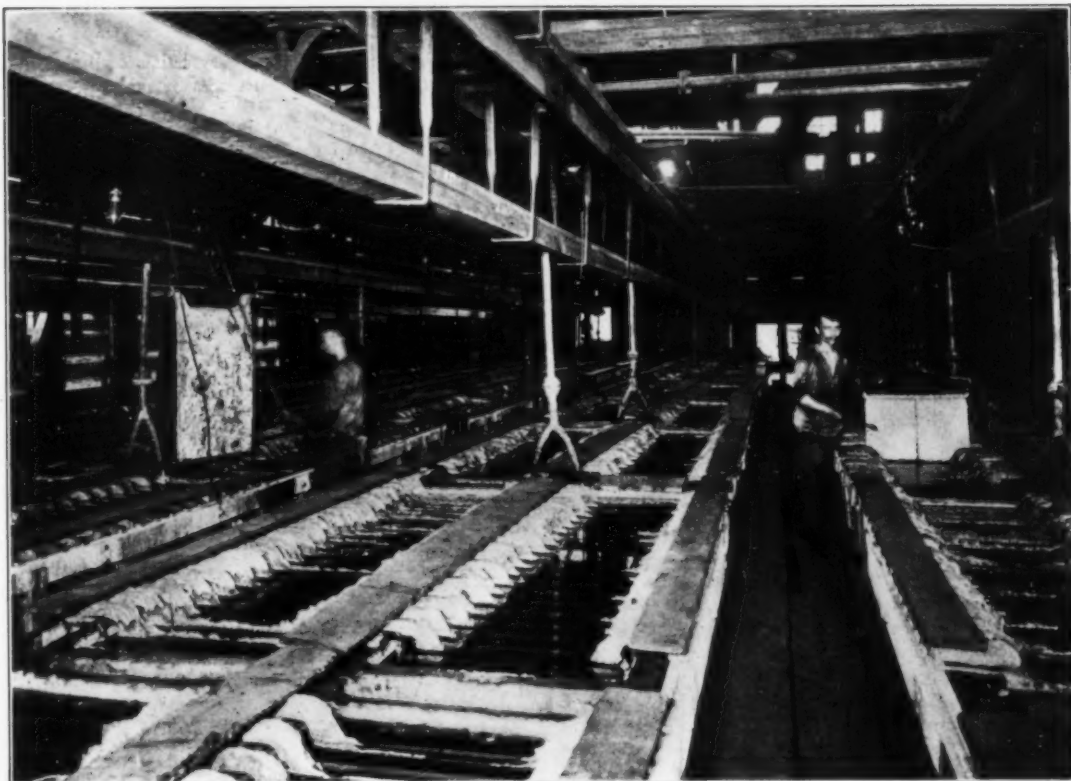
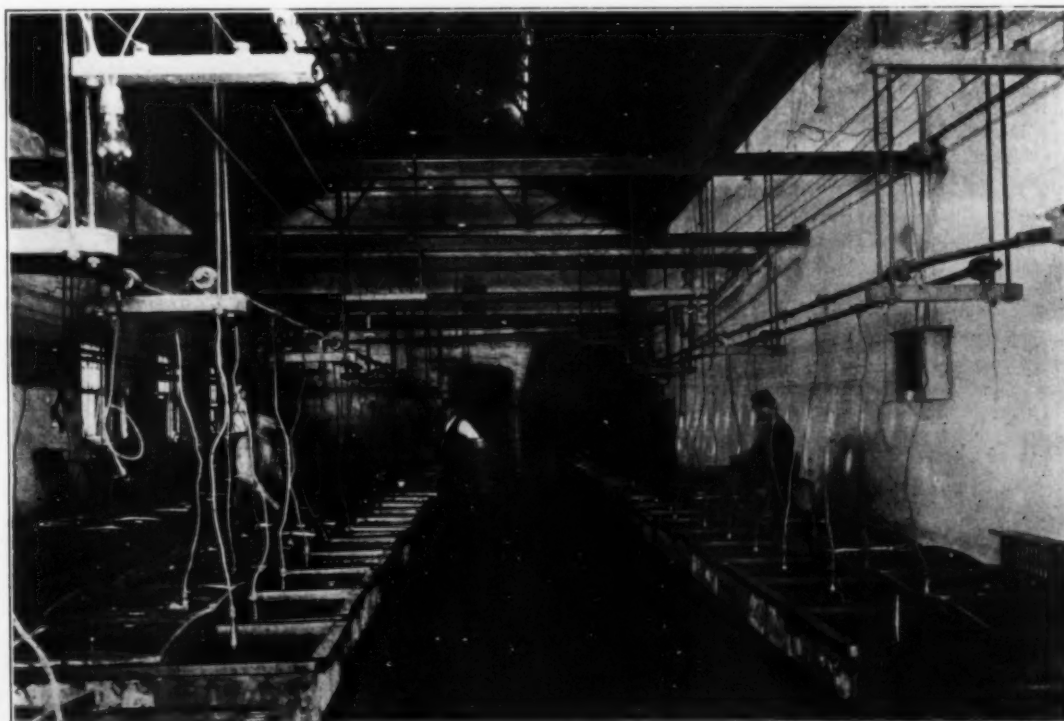FIG. 3.—ELECTROLYTIC COPPER REFINING ROOM, BALBACH SMELTING AND REFINING WORKS.

FIG. 4.—ELECTROLYTIC WINNING OF SILVER FROM THE SLIMES OF THE COPPER REFINERY.

SILVER AND GOLD.

The anode slimes from the copper refinery contain silver and gold. They are regularly cleaned up, melted down, and the ore bullion obtained is parted electrolytically. The solution used for this purpose is dilute nitric acid, which soon changes to silver nitrate and copper nitrate. The copper accumulates in the solution, while the silver is deposited on the cathodes. The gold remains back in the anode mud and is therefrom recovered.

The electrolytic refining room for winning the silver is shown in Fig. 4. There are nine groups of tanks in series, each group containing ten tanks in parallel. The construction of each tank may be easily seen from the illustration. Each tank has a bottom of carbon which forms the cathode. Upon the carbon bottom rests a small silver plate from which connection is made to the negative overhead feeder. The silver is deposited in crystalline form everywhere on the carbon bottom, and is shovelled out at regular intervals.

The anode compartment consists of a wooden box which is placed into the tank, so as to fill about one-half of it. The right-hand row of tanks in Fig. 4 contains these wooden boxes in their right-hand half. These boxes have a slotted bottom, and their construction can be seen from the box leaning against the wall. Into the wooden box a cover of canvass is placed upon which rest the bullion plates which form the anodes and which are connected with the positive overhead feeder. The bullion plate gradually disintegrates, silver and copper going into solution, and the operation is carried on as indicated before.

NICKEL.

In the years from 1894 to 1900 a method of nickel refining was operated at the Balbach works, very pure nickel being produced by an electrolytic process of Mr. Thum from nickel anodes, containing from 95 to 97 per cent Ni, bought from the Orford Copper Company. The details of the process have always been kept secret, although it is understood that two to three millions of pounds of pure nickel have been produced by this method.

For some time, nickel salts have also been produced as a by-product at the Balbach Works and sold to nickel platers. When the company refined blister copper from the Orford Works, the nickel which was originally contained in the copper anodes passed into the solution and accumulated there. When withdrawn, the copper sulphate was crystallized out and a nickel salt remained containing little copper. The latter was then removed by electrolysis.

THE RAPID MEASUREMENT OF THE CONDUCTIVITY OF COPPER ELECTROLYTES.

By Lawrence Addicks.

In making resistance measurements upon electrolytes, we must employ a method in which electrode effects are either absent or so small in proportion to the liquid resistance that they may be neglected. In the Kohlrausch method, if an alternating current of sufficient frequency is used, any such effects counter-balance one another, and the current is also rendered very small by making the cell one arm of a non-inductive bridge. By using induced currents, electrodes can be dispensed with altogether, but, in so far as the writer is aware, lack of sensitiveness has prevented the development of any useful method of this kind. In the liquid potentiometer proposed by Hering[1], the fall of potential in a column of electrolyte carrying a known current is balanced against a known electromotive force by varying the length of the column. At the moment of balance the potential electrodes are carrying no current. A potentiometer with Ostwald calomel electrodes might also be used[2]. Finally, we may treat the problem as if we had an ordinary metallic wire to measure and endeavor to

[1]Trans. A. I. E. E., XIX., 317.
[2]Trans. A. E. S., IV., 96.

choose the dimensions of the apparatus in such a way that the errors introduced are negligible.

The problem can be handled very satisfactorily by the last-named method, when the resistances of acidified solutions of a metallic salt, such as are used in the refining of metals, are to be measured, provided a precision of a couple of percent is sufficient. Some time ago the writer had occasion to measure a large number of such copper electrolytes, the solutions used being those ordinarily employed in copper refining. The Kohlrausch method proved rather tedious and Hering's potentiometer was tried with considerable success. There was difficulty, however, in getting a non-conducting cell of the shape required, at a reasonable cost, that would stand temperatures up to 90° C. without cracking or warping. The sliding electrode was difficult to keep in good condition in the presence of the corrosive liquid, and the expansion of the liquid in the open cell had to be reckoned with in the temperature coefficient runs. After some experimenting an adaptation of
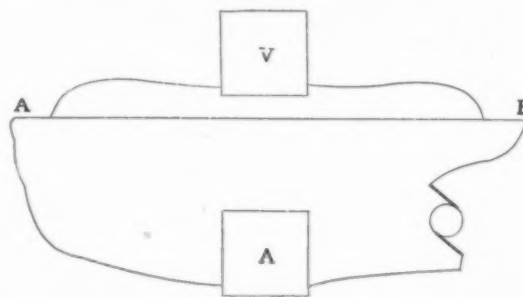

FIG. 1.—ARRANGEMENT OF TEST.

the Munich Shunt method for measuring currents in solid conductors was adopted, and, when the dimensions were properly worked out, the results agreed closely with those given by the other methods.

Figure 1 shows the usual connections for low solid resistances, the idea being to avoid including in the voltmeter circuit the drop of potential across the main current contacts, A and B. These contacts are, in a sense, analogous to electrode effects. Substituting an acidified solution of copper sulphate for AB, we have the following conditions to take care of. First, copper electrodes must be used throughout to avoid polarization effects as far as possible, and contamination of the electrolyte. Wherever current is led in by the copper electrode there will tend to be a gradually increasing concentration of the salt, and vice-versa at the cathodes. These differences in concentration set up counter electromotive forces, and also cause ohmic changes, as the resistance of a solution usually changes very rapidly with concentration. Therefore, the coulombs in the potential circuit during a test should be kept as low as possible. But we must keep the voltage well below the decomposition point of water to avoid any evolution of gas at the potential electrodes. We are limited by this consideration to pressures not exceeding, say, 1.3 volts. With a Weston voltmeter reading 0 — 1.5 volts, the resistance in the potential circuit will be about 150 ohms, and the current will therefore never exceed 0.009 amperes.

We may get this drop between electrodes any distance apart by suitably varying the dimensions of the liquid wire and the main current. This brings up a peculiar condition. The potential gradient between two electrodes, in solutions of the character under consideration at least, is much more steep in the region of the electrodes than would be expected. There is an ohmic resistance in the film next the electrodes that far exceeds in magnitude any counter electromotive force effects. To keep this from unduly weighting results the electrodes must be at least 25 cm. apart.

Figure 2 shows what enormous errors may be introduced

by disregard of these facts. A represents the apparent specific resistance and temperature coefficient of a solution measured between electrodes only 4 mm. apart, and without special po-
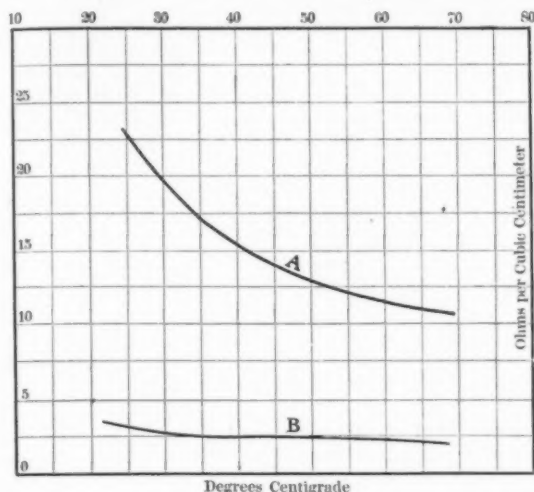

FIG. 2.—RESULTS OBTAINED WITH DIFFERENT ARRANGE-
MENTS OF THE TEST.

tential electrodes. B is for the same solution when measured in the apparatus being described.

The length being fixed as 25 cm. we still have the diameter of the tube and main current to decide upon. 0.3 ampere can be conveniently measured to the precision desired on an ordinary milammeter. This current will require a diameter of
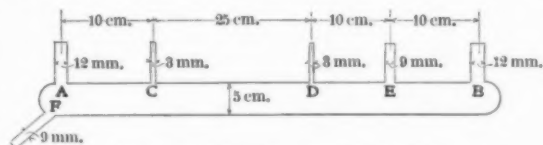

FIG. 3.—DIMENSIONS OF TEST TUBE.

about 5 cm. to give the necessary drop in 25 cm. length with the solutions to be measured. The dimensions of the glass tube employed are given in Fig. 3. The 0.3 ampere current enters and leaves at A and B. The potential leads are at C and D. E is for a thermometer and F is an opening to enable the apparatus to be emptied and washed without dismounting.

The connections are shown in Fig. 4. A current of 5 amperes is used for bringing the solution to the desired temperature, the reversing switch being thrown occasionally. This current suffices to bring the liquid to boiling in a few minutes.
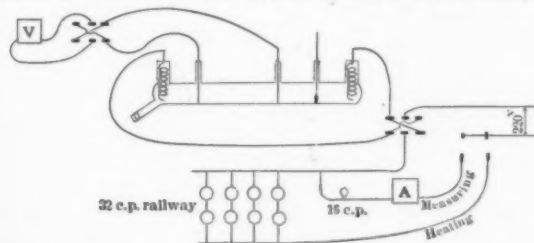

FIG. 4.—CONNECTIONS OF TEST TUBE.

The temperature is uniform throughout the tube to about a degree Centigrade, which is close enough for the results desired. Neglecting the expansion of the glass, the section of the liquid column is independent of the temperature. Experience has shown that no diaphragms are necessary between the cur-

rent and potential electrodes, the distance between them being sufficient to prevent serious changes in concentration by diffusion. Readings are taken with the current flowing in each direction and should be identical. The current in the voltmeter circuit must be calculated from the drop across the voltmeter as shown by its own readings, and deducted from the main current. From Ohm's law and the dimensions of the tube we obtain the resistance per cubic centimeter. The characteristic curve of an electrolyte, as shown in Fig. 2, can be plotted in about twenty minutes.

For practical work in everyday operations, such as watching the effect of growing impurities, the apparatus has proved rapid, and sufficiently exact. The tube costs about a dollar and a half; the rest of the apparatus is to be found in any laboratory.

Perth Amboy, N. J.

APPLICATION OF THE ELECTRIC FURNACE TO THE METALLURGY OF IRON AND STEEL.

A very interesting paper on the general principles underlying the use of the electric furnace in the metallurgy of iron and steel, and on the different types of electric furnaces which have been devised for this purpose, was recently read before the meeting of the American Foundrymen's Association in Philadelphia by Mr. P. McN. BENNIE, of Niagara Falls. In the following we give a condensed abstract of this paper.

Mr. Bennie first discussed the various factors which have so far determined the location and growth of an iron-producing center (meaning the localities where are produced pig iron, steel, etc., and not necessarily finished products). Such factors are the existence of energy, in the form of coal, transportation facilities by rail or water, supply of iron ores, and facilities for getting the products to the market, as well as the nearness of the market. It seems that in general the location of iron-producing centers has been determined, not so much by the presence of iron-bearing measures, as by the presence of the energy necessary for the reduction and refinement, which in ordinary metallurgy is supplied by coal, coke and charcoal. Recently we have witnessed, it is true, a partial compromise in this respect, in the growth of iron industries in the vicinity of Buffalo, where the Susquehanna Co. and the Lackawanna Co. have erected enormous plants. But the location of plants there is due to the fact that fuel can be transported very cheaply from the Pennsylvania fields, while ores can be brought by water from the upper lakes at a minimum cost. Then Buffalo possesses unusually good transportation facilities to the consuming centers, by rail and water, through the great lakes.

If it should be possible to replace a portion of the carbon energy by electrical energy, derived at a relatively low cost from water power, or from the utilization of waste blast furnace gases, or from gases produced from anthracite culm, we may then expect to see metallurgical operations carried on under new conditions and industries spring up in new and unexpected places, with relation to supply of raw materials. Mr. Bennie was, howeer, careful to emphasize that it should not be imagined that the electric furnace will do anything that is demanded of it, or that it can be successfully applied under all sorts of conditions. That is a common error into which many have fallen who should know better. The electric furnace can do some things and do them better than any other kind of furnace, but it cannot do everything. From an economic point of view it is necessary to find out any of the particular cases the eleric furnace can be applied so as to offer advantages over other methods. It should be borne in mind that although electricity is the most flexible and tractable of the forms of energy, it is as a metallurgical agent generally the most costly. It should therefore only be employed with a thorough grasp of the conditions; and its use should be restricted to those applications where its superiority is clear.

Mr. Bennie then reviewed the progress made abroad and explained the peculiar reasons which have so far caused the progress to be greater abroad than in this country. He then gave a classification of the different purposes for which electric furnace methods have been applied in the iron and steel metallurgy. He distinguishes four classes, of which class 1 is designed as an adjunct to blast furnace working, class 2 as a partial dependent process, while classes 3 and 4 are entirely independent. These four classes are as follows:

No. 1. Treatment of molten pig iron as it comes direct from the blast furnace, for the purpose of refining and converting it into steel of certain grades. This may be called the electrorefining of steel.

No. 2. Treatment of cold pig iron, or a mixture of pig and suitable scrap, to produce iron and steel.

No. 3. Direct reduction of iron from its ores, and if desired, subsequent refinement into steel, as a practically continuous process, beginning with the raw ores.

No. 4. Production of various ferro-alloys, by either of the following methods:

(a) Starting with a mixture of iron ores and ores of the metal to be alloyed, or

(b) Starting with a mixture of pig iron and minerals to be reduced and alloyed therewith.

The lecturer pointed out the characteristic features of these four classes as follows:

Class 1. Treatment of molten pig iron direct from blast furnace.—The electrorefining of molten pig iron direct from blast furnaces, or cupolas, presents certain advantages over treatment of cold metal. For instance, the considerable amount of heat contained in the hot metal is utilized. Also, hot iron has a higher electrical resistivity than cold iron, so that when it is desired to conduct electrical refining by producing the required temperature by Joulean heat, this is more easily carried out by starting with hot metal. For refining purposes, furnaces of the resistance type seems well adapted; that is, where the temperature of the bath is maintained by the generated heat of an electric current passing through the metal itself.

Class 2. Treatment of pig iron, or pig iron and scrap, starting with the metals in the cold state.—The class of electrical furnaces employing this method comprises those in which the high temperature of the electric arc is used to start the process, and later when a sufficient quantity of molten metal has been produced in the hearth, the current is made to pass through the slag floating on top of the bath. The slag has a higher resistivity than the molten metal, and the heat thus generated is taken up by the fluid metal beneath.

Class 3. Direct reduction from the ores.—Processes starting with the ores themslves do not seem destined to wide application in the United States. In the present state of development of electrometallurgy, furnaces can be designed for but limited capacities, compared with modern blast furnaces, and it is doubtful if pig or even steel could be produced in electrical furnaces at a sufficiently low cost to justify this class of operations. Where it is desired to refine the reduced iron into steel, as part of the process, it possesses a greater interest.

Class 4. Production of ferro-alloys.—This class of furnaces has been applied for a number of years with considerable success, and its value for the purpose is undeniable. It already occupies a permanent place in the metallurgical scheme, as steelmakers are dependent upon electrical methods for many ferro-alloys not otherwise obtainable, such as ferrosilicon having a high percentage of silicon, high-grade ferromanganese, ferro-chromium, ferro-alloys of titanium, molybdenum, tungsten, vanadium, etc.

From the electrical point of view the various styles of furnaces are divided by Mr. Bennie into the following:

(A) *Electric arc furnaces.*—In this class of furnace, carbon electrodes are used, the heat being generated in the arc itself and absorbed by the material beneath, which is generally out of actual contact with the arc. For this class of furnaces, those of Ernesto Stassano and Ramon Chavarria-Contardo may be considered as typical.

(B) *Arc-resistance furnaces.*—In this class carbon electrodes are employed to convey the current to the mass under treatment. An arc is general used to start the bath, when the current is passed through the molten material, or through a layer of slag floating on top of the bath, according to the disposition of the electrodes. To this class belong the furnaces of Charles Keller, Paul Heroult, M. Harmet and E. A. Sjöstedt.

(C) *Resistance furnaces, with granular resistance.*—There are not many examples of this method of generating heat, although it certainly offers distinct advantages peculiar to itself. Paul Girod seems to have made the most progress with this type.

(D) *Resistance furnaces, by direct heating.*—These are refining furnaces, without carbon electrodes. In this class of furnace, as in the preceding class, an effort is made to dispense entirely with carbon electrodes in contact with the bath, to avoid introduction of carbon from the electrodes. Gustave Gin has developed one style of furnace of this kind, in which heavy currents are passed through the molten metal and the Joule effect is utilized to bring the material to the desired temperature.

(E) *Refining furnace heating by induced currents.*—In this type of furnace the heat is produced by induction, using the material as the secondary in a transformer. The credit for working out this ingenious type belongs to F. A. Kjellin, of Gysinge, Sweden.

Mr. Bennie then gave a review of various types of furnaces which have been in practice on a more or less large scale and first dealt with electric furnaces, describing the Stassano furnace. (Electrochemical Industry, vol. 1, March, 1903, page 247.) The author stated that while the original company exploiting the Stassano process was compelled to suspend work on account of lack of funds, yet the Italian Government agreed to give Capt. Stassano further assistance, so a furnace of about 125 hp. was built at the Royal Foundry Arsenal in Turin. This furnace was started on June 14, 1903, and, according to recent advices, is capable of turning out 2500 to 3000 kgs. of metal per day, with 120 to 140 hp. The quality and yield are stated to be much improved over previous tests. One thousand amperes are employed at 80 volts. The production is at the rate of 55 pounds per horse-power day.

Ramon Chavarria-Contardo, at Paris, is also working with a furnace employing radiated heat from the arc, but no data are available as to the product. The general construction of the furnace, as seen by Mr. Bennie, is similar to Stassano's.

The author then discussed resistance furnaces in which electrodes are plunged into the materials to be reduced and fused. Generally the process is started with a small quantity of material and an arc is sprung which quickly reduces the materials to a fluid state. Further material is added until finally the furnace body is comfortably filled, when fusion goes on quickly and continuously. In most cases when the furnace is under full way, the electrodes are maintained at the level of the layer of slag flowing above the liquid bath. As an example, Mr. Bennie described the Keller process (see Electrochemical Industry, vol. 1, January, 1903, page 162; vol. 2, July, 1904, page 280).

The author then dealt with the Harmet process. Mr. H. Harmet, who is chief engineer of the Société des Fonderies, Forges et Acieries, of St. Etienne, France, has designed several types of furnaces for the electric treatment of iron ores, some being partly electrical and others wholly electrical. Mr. Bennie remarked that Harmet is essentially a metallurgist and his furnaces show that he looks at the problem through the eyes of the metallurgist rather than the electrical engi-

neer; that it is easy to trace in his designs the influence of blast furnace practice. (Furnaces patented by Harmet were described in ELECTROCHEMICAL INDUSTRY, vol. 1, 1903, page 422, 587 and 588.)

Some estimates have been published on the Harmet process, giving a cost of $5.60 per ton. Mr. Bennie remarked that this figure is wholly misleading, since Mr. Harmet himself has stated that about 3600 hp.-hours are required by this process to produce one ton of steel from the ore. Taking the average horse-power-year as 8000 hours, allowing for stoppages, 3600 hp.-hours equal about 0.45 hp.-year, which at $12 per year
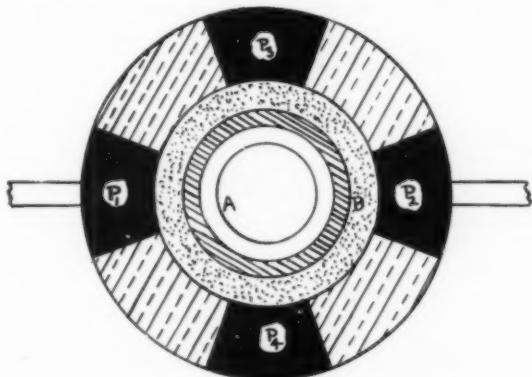

FIG. 1.—HORIZONTAL SECTION OF GIROD STEEL FURNACE.

P₁₂₃₄ are the electrodes, A the crucible, B the granular resistance material.

would be about $5.40 alone for electrical energy, and it is doubtless to the power cost that the above published figure of cost refers. M. Harmet's process is being studied by himself in conjunction with Mr. Paul Girod, of Albertville.

The author then discussed the Heroult process (see ELECTROCHEMICAL INDUSTRY, vol. 1, pages 63, 287, 449, 461 and 467), and then passed over to the Sjöstedt furnace (ELECTROCHEMICAL INDUSTRY, vol. 1, June, 1903, page 353; vol. 2, April, 1904, page 153, and May, page 188 and 207). Mr. Bennie remarked that outside of a few minor details, as to cooling arrangements, etc., the furnace used by Sjöstedt does not differ materially from the Siemens electric furnace in use ten years ago; it rep-
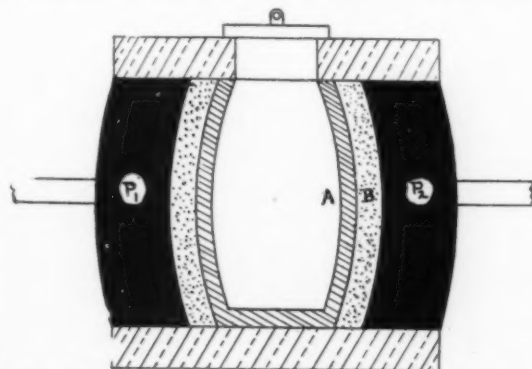

FIG. 2.—VERTICAL SECTION OF GIROD STEEL FURNACE.

resents a type that has been thoroughly tried by several electro-metallurgists and abandoned as being very inefficient; better results would no doubt be obtained on a larger scale and by using a more highly developed type.

The author then passed over to another type of furnace that is a resistance furnace with superficial resistance. Mr. Paul Girod, electrometallurgist to the Société Anonyme Electro-metallurgique, at Albertville, Savoie, France, has devised a

furnace which consists of a crucible made of refractory material, surrounded by a resistance of graphite, in granular form, or even agglomerated. The carbon electrodes are placed equidistant around the resistance material surrounding the crucible; between the carbon electrodes refractory bricks are fitted. Refractory material for thermal insulation is also placed below and above the crucible, with an opening for charging and discharging purposes.

The whole is mounted on trunnions so that it can be oscillated or tilted even while running. These furnaces are of about 200 hp. each, with a normal pressure of 0.25 volts. By this method very uniform heating is obtained. It is possible to fuse easily bronze, steel and other metals. Its use has also been suggested for glass, for which it seems peculiarly adapted.

The temperature can be maintained at 500° C., if desired, but can also be raised to 3500° or 4000° C. In fact, in such furnaces, Girod has been able to fuse pure vanadium and ferro tungsten, which are fused only with the greatest difficulty. These furnaces, of about 150 kw., are said to produce 2000 kgs. or 4400 pounds of steel per day. In addition to the works at Albertville, another factory was started several months ago at Courtepin, near Fribourgh, Switzerland; they also have a third works at Ugine, France. This looks like a permanent entry of electrometallurgy into the industry of steel manufacture.

The author then went over to a discussion of the Gin process (ELECTROCHEMICAL INDUSTRY, January, 1904, page 20), and of the Kjellin process (ELECTROCHEMICAL INDUSTRY, vol. 1, December, 1903, page 576), and made a brief reference to the very original process of Marcus Ruthenberg (ELECTROCHEMICAL INDUSTRY, vol. 1, page 58, 84, 202, 482, 494).

In summing up, Mr. Bennie said that the electrometallurgy of iron and steel has already left the domain of the laboratory and experimental plant, and taken on the serious aspect of an established industry. The electric furnace has its limitations, which it would be well to bear in mind. Even its most ardent advocates do not consider it a menace to the older methods, but rather as a new and useful adjunct to present metallurgical practice. It should be noted that while some processes are designed to perform the *direct reduction* of iron ores, the general tendency is to use the electrical energy for production of steel, and particularly as a refining agent in treatment of pig iron and scrap. For this field of usefulness, the electro-refinery seems destined to occupy a permanent place in the art.

When we shall witness the combination of the blast furnace for cast iron; the Bessemer converter for common steel, and
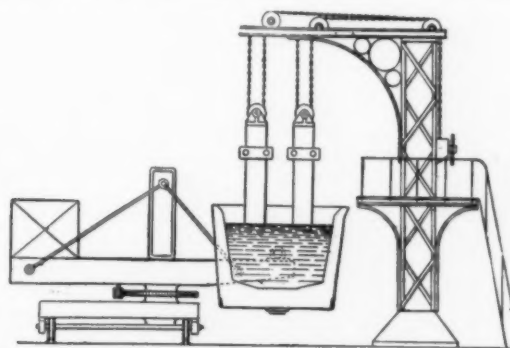
FIG. 3.—THE ELECTRIC REFINING FURNACE AS AN ADJUNCT TO FOUNDRY PRACTICE.

the electrical refinery using energy generated from waste blast furnace gases, making higher grade steels, then industrial metallurgy will have attained the high-water mark in the utilization of the heat energy of coal. In attacking the older art from the crucible steel standpoint, electrometallurgists are undoubtedly hitting at the weakest spot.

In conclusion, Mr. Bennie makes some reference to the application of the electric furnace to foundry practice. Take a

foundry with a number of cupolas. It would be possible to arrange an electric refining furnace so that it could use the product of any one or of all of the cupolas. The author exhibited an illustration showing how this could be done. He has a furnace body in the form of a ladle, placed upon a carriage, suitably counter-balanced, and able to swing free in a circle. It may receive its charge and then be placed under the arrangement for carrying electrodes. By lowering the electrodes and turning on the current, refining is carried out. Without using excessive currents, liquid iron may be converted into steel of good quality.

Mr. Bennie offered this to the enterprising foundry managers as a suggestion of ways for employing their full capacity at all times; for improving the quality of their castings, for converting a portion of their product into steel. For a small cost, a foundry arranged for the manufacture of cast iron could undertake steel castings and augment considerably its sphere of commercial activity. The author remarked that many foundries are already equipped with electric power, and that in discussing the matter with a well-known central station manager he was assured that the station would welcome any proposition which would take power during their periods of light load, say from 10 p. m. to 1 p. m. next day, and could make very low rates for such intermittent power to be taken at definite times.

The author gave a final word of warning, however. The construction of electric furnaces is not a small matter. Results of a kind can be obtained by throwing four walls together and sticking a couple of electrodes in and calling that an electric furnace. Satisfactory results require careful treatment in all the phases of electric furnace construction and operation, as well as considerable experience. Many processes have been failures, due simply to the fact that those who tried them did not understand electric furnaces and had developed a thoroughly inefficient practice. Money is saved in the end by a thorough understanding of what one is going to do before doing anything.

A CONTRIBUTION TO THE THEORY OF THE JUNGNER-EDISON ACCUMULATOR WITH CONSTANT ELECTROLYTE.

BY M. U. SCHOOP.

(Concluded from page 276.)

IV.

The changes of volume caused by the passage of the current are considerably greater for the nickel electrode than for

discharge consists simply in oxygen being given off (at the rate of 0.3 gram per ampere-hour), we might expect a corresponding diminution of weight. The experiments prove, however, that on the contrary the nickel electrode, when weighed in the electrolyte, gets heavier during discharge with any current whatsoever and gets lighter during charge. This surprising fact is caused by the contraction of the nickel material, or, in other words, the specific weight of the active mass of nickel increases during discharge and a smaller amount of electrolyte is now displaced by the plate than before. The absolute weight of the nickel plate decreases, of course, during discharge, and that of the iron plate increases by the same amount. This can be proven by conducting the experiment in the manner mentioned before, by removing the plates after the test from the containing vessel and placing them on the scales. Such a measurement, however, of the absolute changes of weight does not give any information as to the changes of volume of the active materials which have taken place or as to the concentration changes of the solution. This is evident, for instance, from the following experiments.

The nickel electrode, after having been fully charged, was left at rest for two days, so that any concentration differences existing in the cell should be annihilated. The nickel electrode was then removed from the vessel, the solution was washed off from its surface under a spigot, and the electrode was dried at its surface by means of blotting paper and placed on the scale. The plate weighed 214 grams. It was then placed in a cell which was discharged. After 11.7 ampere-hours had been taken out and the cell had been left at rest for 16 hours, the nickel electrode was handled in the same way, the manipulation requiring not more than 2 minutes, and the weight was again determined and found to be 224.7 grams, which means an increase of weight by 40.7 grams. The decrease of weight due to the removal of oxygen is 0.3 × 11.7 = 3.51 grams, and is therefore more than counterbalanced by the increase of the volume of liquid in the pores during discharge. It is also possible that in spite of the long period of rest the existing concentration differences in the solution had not been completely annihilated.

A similar experiment with an iron electrode from which 10.5 ampere-hours were taken during discharge, gave an increase of weight of 4.4 grams, instead of 10.5 × 0.3 = 3.15 grams. In both cases the agreement between calculation and experiment is poor. The difference between the measured and calculated value is not as great with the iron electrode as with the nickel electrode; it may again have been mainly due to an increase during discharge of the volume of the pores filled with liquid. After a few experiments, no further tests were made by this method, since the prospects of getting results which would agree with each other were very poor.

DISCHARGE OF NICKEL ELECTRODE WITH 0.5 AMPERE.

For the auxiliary electrode (through which no current passes, but which is simply used for determining the potential) the same small nickel electrode was used as in the former tests. For the sake of simplicity its potential is taken as zero in the diagramatic representation of the results in Fig. 5. The potential of the nickel electrode shows the features characteristic for this type of electrode. At the beginning of discharge, for the first ampere-hour, the curve is above
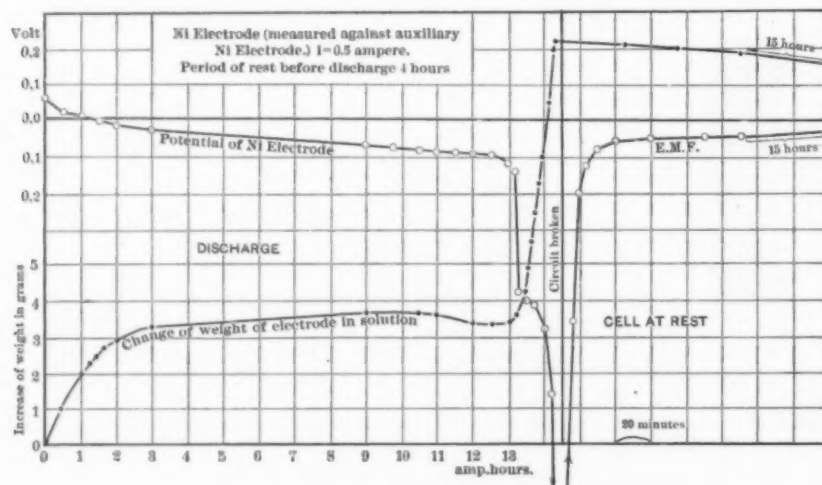
FIG. 5.—DISCHARGE OF Ni ELECTRODE WITH 0.5 AMPERE.

the iron or cadmium electrode, as was already noticed. If the reaction which takes place at the active nickel material during

the axis of zero, i. e., the potential of the nickel electrode under test is higher than potential of the auxiliary electrode during the first two hours of the discharge with 0.5 ampere. After that time the curve goes down slowly and continuously, and when 13 ampere-hours have been taken out of the plate the potential — 0.13 volt is reached. An extremely steep voltage drop now occurs, the potential dropping in a nearly perpendicular line down to — 0.5 volts. During the next two hours (corresponding to one ampere-hour) the voltage continues to drop, first more slowly but then drops again rapidly. The value which was finally reached is — 1.325 volt, the electrode being about to be reversed in polarity. The current was then interruped, and the change of e. m. f. observed afterwards is shown at the right-hand of Fig. 5. Like in the lead accumulator, the curve is a logarithmic one, but is much less rounded. The potential reached after one hour is — 0.05 volt, and after 15½ hours a constant value — 0.03 volt is reached.

With respect to the change of weight the nickel electrode behaves in a very peculiar way, as was already noticed. The weight of the plate in the solution increases quickly at the beginning of the discharge, until about three ampere-hours have been taken out of the plate. For a considerable time afterwards, the variation of weight is small. After eleven ampere-hours a slight, but perfectly evident, decrease of weight is observed. Then, in the moment when the potential undergoes its rapid drop, an enormous increase of weight is observed, caused by the contraction of the active material. The plate suspended on the balance now increases so quickly in weight that the motion of the balance beam may be observed with the naked eye. After 14.3 ampere-hours the increase of weight was 11.2 grams. The discharge circuit was then broken and the change of weight of the electrode was observed while the cell was at rest. As the curve shows, diffusion annihilates the existing concentration changes and causes a very slow but continual variation of weight. After

do with concentration changes of the solution in the pores; this appears to be proven by the form of the weight curves.

Concerning the peculiar form of the curve of change of weight, it is to be remarked that it is not absolutely free from criticism in so far as the period of rest which was interposed between charge and discharge was only four hours, and, as found by later experiments made for this purpose, this period is not sufficient to annihilate all concentration changes produced during charge. I regret that in some of my experiments this fact was not sufficiently taken into consideration since I first had assumed without proof that sufficient uniformity of concentration in all parts of the cell would be reached within a few hours.

The same experiment was therefore repeated, but after the cell had been charged it was left at rest for more than thirty hours. The results are given in Fig. 6, and show clearly the different composition of the liquid in the pores at the beginning of the discharge in the two cases. It is, perhaps, superfluous to remind the reader that the absolute changes of weight of the solid portions of the electrode are exactly the same in both cases, and that the difference of the two weight curves is produced only by the difference in the diffusion phenomena. We know that during charge the liquid in the pores of the iron or cadmium electrode becomes more concentrated and that in the pores of the nickel electrode becomes more dilute. At the end of the charge, the active nickel material is therefore impregnated with dilute solution, so that the relative change of weight of the electrode in the solution during discharge will be more or less evident, according to the degree to which the concentration of the solution has already become uniform at the beginning of the discharge, and this degree depends on the length of the period of rest interposed between charge and discharge.

It is very peculiar that the variation of weight in Fig. 6 changes its sign towards the end of the discharge, i. e., after a certain number of ampere-hours there is no longer an increase of weight, but a decrease of weight. The same observation is made again and again at low discharge rates, while for higher discharge rates the influence manifests itself in so far as the rising weight curve becomes more or less flattened. Qualitatively the weight curves during discharge in Figs. 5 and 6 are not different, while the potential curves during discharge are exactly the same.

In the test represented in Fig. 6, the discharge with 0.5 ampere was followed immediately by a charge with the same current. In general the results which are obtained by my method are less reliable during a charge than during a dis-

FIG. 6.—DISCHARGE AND CHARGE OF Ni ELECTRODE WITH 0.5 AMPERE.

ninety minutes a decrease of weight of only 0.3 grams is observed, and after fifteen more hours the decrease of weight is still only 0.4 grams.

After twenty hours' rest it was tried to continue the discharge of the plate with 0.5 amperes, but the plate appeared to be absolutely exhausted since the potential dropped immediately to zero.

The "electrochemical fatigue" of the nickel electrode has therefore a character essentially different from the "fatigue" of the lead accumulator which has been designated by Dolezalek as concentration polarization or exhaustion of electrolyte. The slow decrease of voltage has little to

charge. The reason is that during a charge gas bubbles are soon developed (which accounts for the low efficiency of the nickel iron accumulator). These gas bubbles are, of course, sources of error in the weighing. At the beginning of the charge, the voltage undergoes a rapid increase and increases then slowly and continually in a straight line from + 0.06 to + 0.11 volt. The weight curve for a charge does not show that sudden bent which is the characteristic feature of the weight curve during discharge. This proves that the change in the different states of oxidation does not set in immediately. The weight curve would probably show a picture analogous to the discharge weight curve, if after completed
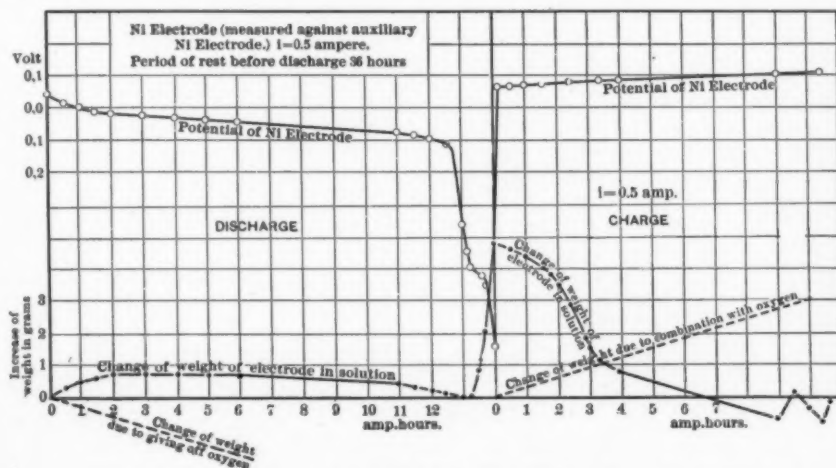
discharge the cell was left at rest for a sufficient period, so as to produce uniformity of concentration. The irregularities observed in the diagram at the end of the charge are due to gas bubbles.

DISCHARGE WITH 15 AMPERES.

From the large number of experiments made with the suspended nickel electrode, I will also give the results obtained for a discharge with 15 amperes. During discharge the liquid in the pores of the nickel electrode becomes more concentrated, while it gets more dilute during charge, and these concentration changes will be the greater the higher the rate of discharge or charge; it is therefore to be expected that this manifests itself in the curve of the change of weight. In fact, the experiments prove the correctness of this conclusion. It is to be remarked, however, that the real picture of the diffusion phenomena at the electrode is probably somewhat covered by the fact that at high current densities a considerable increase of temperature takes place at the electrode. This causes an expansion of the plate which must manifest itself in a decrease of weight of the suspended electrode in the solution. The heat effect is the sum of the Joulean effect, i^2r, the dilution heat at those places where concentrated solution is in contact with dilute solution, and finally the heat liberated by the exothermic reaction. In this experiment, as in those made with a low discharge rate, it was found that it is necessary to leave the cell at rest after completed charge for quite a long period before it is discharged, as otherwise the results obtained do not agree with each other.

The discharge curve of the nickel electrode at 0.5 ampere is not dissimilar to that of a lead peroxide plate, if, in the case of nickel, we do not consider the last small portion of the curve. For a discharge at the high rate of 15 amperes, this is no longer the case. The curve here consists of several

into the pores of the plate. With the nickel electrode the reverse phenomenon takes place, the weight decreasing on account of diffusion of concentrated solution from the pores of the plate to the outside solution of normal concentration.

To enable an easy comparison of the speed of diffusion for the iron electrode with that for the nickel electrode, the weight curve for the iron electrode (while the cell is at rest) is taken from Fig. 3 (page 275 of July issue) and plotted in Fig. 7 in form of a dotted curve; to make the comparison of the speeds of diffusion easier this curve is plotted reversed, that is, the dotted weight curve of the iron electrode in Fig. 7 represents an increase of weight, while the weight curve of the nickel electrode represents a decrease of weight.

Under the supposition that the mean concentration of the electrolyte remains unchanged as to its contents of KOH during the passage of the current—which is certainly a justified assumption—we may conclude that the concentration of the solution in the pores of the one electrode increases in exactly the same degree as it decreases in the pores of the other electrode, and vice versa. One might, therefore, perhaps expect that after completion of a discharge, made under otherwise equal conditions, the weight of the nickel electrode should decrease by exactly the same amount as the weight of the iron electrode increases. However, in such a conclusion one overlooks that the changes of the volume of the two active masses are very different, and this explains why the experiments show that (even after discharges of the same number of ampere-hours) the equalization of concentration by diffusion is not represented by identical curves for the iron and nickel electrode. Moreover, it is possible that so-called concentration currents occur also with the electrodes of the alkaline accumulator, and that they influence more or less the speed of diffusion in a similar way as in the lead accumulator according to the researches of Dolezalek.

FIG. 7.—DISCHARGE OF Ni ELECTRODE WITH 15 AMPERES.

The change of the volumes of the active masses of nickel and iron electrodes may also be observed in such a way that a small accumulator is enclosed in a containing vessel and the volume changes, due to the discharge of one ampere-hour, are read directly on a calibrated capillary tube connected to the top of the containing vessel. During the experiment, the apparatus is preferably placed in a large water bath of constant temperature. I found in this way a decrease of volume
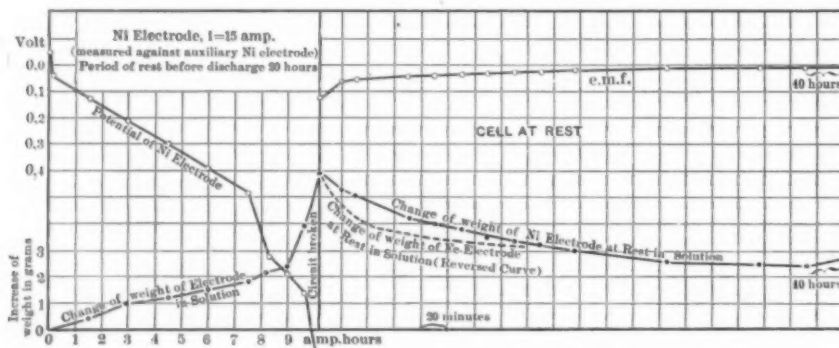
straight lines which can be sharply distinguished from each other. The first drop of voltage at the beginning of the discharge is now more rapid and the whole curve is much more declined than before; this is only natural, since the capacity is now smaller. Exactly after 10.2 ampere-hours the current was interrupted and the changes of e. m. f. (measured against the small auxiliary nickel electrode), as well as the variations of the concentration of the electrolyte were observed. The results are given in Fig. 7.

The curve giving the increase of e. m. f. after the conclusion of the discharge is similar to the former curves. After six hours a constant value of — 0.01 volt is reached. It is interesting to compare the forms of the e. m. f. curves after the completion of the discharge while the cell is at rest, for the nickel and the iron electrode. A comparison of the two curves of the variations of weight while the cell is at rest for the nickel and iron electrodes is also instructive.

With the iron electrode, after the discharge has been discontinued, a rather quick increase of weight takes place, caused by solution of normal concentration rushing from the outside

of 0.16 cubic centimeter per ampere-hour discharge. But it may be emphasized that this value refers only to the slow voltage drop which is of practical importance, and I do not claim that this figure is very exact. After the sudden drop of voltage, the column of liquid in the capillary tube dropped very quickly below the calibrated scale so that further readings were impossible. Dolezalek found by a similar experiment for the lead accumulator an increase of volume of 0.42 cc. per ampere-hour discharge. (Dolezalek, The Theory of the Lead Accumulator, translated by C. L. von Ende, page 104.)

I like to call attention to the following experiment. Although it does not belong to the series of tests under discussion in this paper, yet it is very suitable to emphasize the very different behavior of the lead accumulator and alkaline accumulator with respect to diffusion. If two lead peroxide plates which are discharged to one-third, are connected, as shown in Fig. 8, and if a current is sent through this system in a certain direction, the following observation is made when the charging circuit is broken and the two electrodes are

short-circuited through an ammeter. The ammeter shows a very strong current which is directly proportional to the concentration difference between the concentrated acid in the pores of the charged electrode and the dilute acid in the pores of the discharged electrode. This concentration difference, and therefore the current observed in the ammeter, will be the stronger the greater the current was which was sent through the system before. The short-circuit current is, of course, a maximum at start and decreases rapidly and continually until no longer any concentration difference exists between the acids in the pores of the two plates.

If the same experiment is made with charged nickel electrodes, they show an entirely different behavior. Under exactly the same conditions of the experiment (with equal dimensions of the plates and equal currents) the short-circuit current is smaller for nickel electrodes than for lead peroxide electrodes; moreover, the curve of the short-circuit current indicates that in this case the short-circuit is due less to the different concentrations of the solutions in the pores, but rather to different states of oxidation of the two nickel masses. The correctness of this conclusion may be proven, if, before we short-circuit the electrodes through the ammeter, a long period of rest is inserted during which the changes of con-
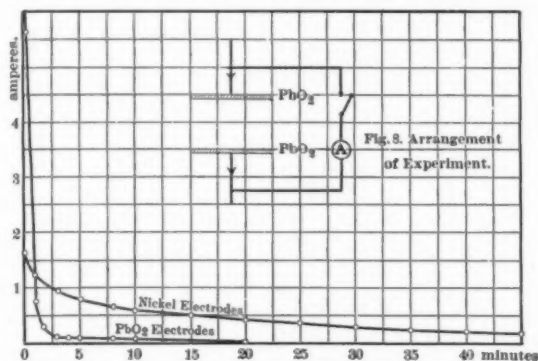

FIG. 9.—CURVES SHOWING DIFFERENT BEHAVIOR OF NICKEL AND LEAD PEROXIDE ELECTRODES.

centration disappear. In spite of this period of rest, a strong short-circuit current is observed with the nickel electrodes, while with the lead peroxide electrodes, the short-circuit current completely disappears under the same conditions. The curves in Fig. 9 give the results of such comparative tests and do not need any further comment. It may be remarked that KOH solution and sulphuric acid of maximum conductivity were used and that the plates of nickel and lead had approximately the same capacity.

* * * * *

The results of the experiments described in this paper may be briefly summarized as follows:

(1) The method of measurement, using an electrode suspended on a scale, enables one to study the changes of volume of the active masses of the electrodes and the diffusion phenomena during and after the passage of the current.

(2) The changes of volume are greater for the active nickel mass than for the active iron mass, and they are the greater the further the discharge is pushed.

(3) Roeber's theoretical conclusions were confirmed by the experimental investigation. At both electrodes, strong concentration differences are produced during the passage of the current, while the concentration of the free electrolyte between the plates, as well as the average concentration (i. e., the total content of KOH in the electrolyte) remain constant.

(4) During the discharge the solution becomes more concentrated in the pores of the nickel electrode and becomes more dilute in the pores of the cadmium or iron electrode; during charge the opposite effect is observed.

(5) A so-called concentration-polarization, i. e., exhaustion of the electrodes due to dilution of the solution in the pores (corresponding to the exhaustion of sulphuric acid in the lead accumulator) seems to exist to considerable extent in the iron electrode. The iron electrode, therefore, shows a "recovery" of potential (increase of e. m. f.) after the interruption of the current, due to the diffusion of the electrolyte into the pores of the plate. It is probable that the increase of temperature has also an essential influence on the capacity of both electrodes.

(6) The measurements appear to justify the conclusion that the alkaline accumulator with constant electrolyte has a higher temperature coefficient than the lead accumulator, and that the temperature coefficient is positive.

* * * *

Postscript.—The nature of the reactions at the Fe and Ni electrodes during electrolysis is not yet exactly known. Especially the supposition that at the cathode iron is dissolved would be in contradiction to the observations of Hittorf on the passivity of iron. The ionic reactions may perhaps be written $Fe \rightarrow Fe^{..}$ and $Fe \rightarrow Fe^{...}$, besides formation of Fe_3O_4. The ionic reaction at the anode seems to be $Ni^{...} \rightarrow Ni^{..}$. According to measurements of Prof. F. Foerster (as communicated to me in a private letter) the temperature coefficient is positive and is about 0.0007 (in the average) for one degree between 0° and 30° C. The e. m. f. therefore increases with the temperature. The temperature coefficient was found to be independent of the concentration. This agrees with Jungner's theory, which requires that the electrolyte remains constant.

Cöln-Lindenthal, Germany.

AN INDEX TO ELECTROCHEMISTRY AND ITS APPLICATION.

At the last meeting of the American Electrochemical Society in Washington, a paper was presented by Mr. Adolph L. Voege, formerly an engineer of one of the Niagara electrochemical concerns and now a resident of Zurich, Switzerland, on a card index for electrochemistry and its application. Mr. Voege's paper was submitted to the Society with a letter from Prof. W. D. Bancroft, who recommended the scheme of Mr. Voege to the attention of the members of the Society.

On account of limitations of time, the paper was not read at the meeting and for this reason we were unable to give an abstract of the same in our report in the May issue. The paper has now been printed in the fifth volume of the Transactions which has recently been issued. Since Mr. Voege's intentions certainly deserve the interest and support of all interested in elctrochmistry, we give his paper, which was prepared by him in collaboration with Dr. H. H. Field, the director of the Concilium Bibliographicum in Zurich, nearly in full as follows:

When a piece of scientific experiment is undertaken at a university to-day, the advice is to devote two-thirds of the time to the literature of the topic. The detailed study of the works of predecessors must obviously be done personally; but no one who has made the attempt will fail to appreciate the enormous difficulties that exist to-day in finding out what has been published the world over on any given topic. And yet let the student overlook one single reference, published, perhaps, in a foreign tongue and in an obscure journal, and he may suddenly awake to the desolating realization that his long months of study have been useless and that he has merely rediscovered a fact long since known. Perhaps the overlooked paper may contain suggestions which, if known in time, would have given a totally different trend to his work, so that he falls short of discovering vital features and finds that his labor has been almost useless; he may even find that another, better posted on what has already been done, has with far less pains come to valuable results, which would have been his, had he only learned in time of that earlier work. A

manufacturer sees a by-product more or less wasted, when, perhaps, in some other land this same product is turned to good account. Who has such encyclopædic knowledge that he can advise him? Think of the inventors who are wasting their lives by not being able to know in time the partial solutions their problems have already received. Who can tell how many unforseen applications may be made of a process devised merely to meet one special need?

These are things that individual effort can never attain. Here organization is the salvation—a central agency where the work will be done once for all. Personal conviction and the advice of leaders in electrochemistry brought this need home to the author some time ago, and he resolved to devote his life to the task, if he could only count on the support of the very persons who would be benefited by his work. It is evident that foreign work is least known in America, and during the author's stay in Germany, he set to work to gather all the information possible in the great libraries. Later, chance brought to his knowledge the fact that zoölogists had met similar needs by an organization such as he had planned, and that the same was in successful operation in Zurich, Zwitzerland, under the name of Concilium Bibliographicum. It seemed at once to the author that if a theoretical science such as zoölogy could find advantage in such an institution, this must be still more the case for a science where great financial interests are involved, and he found, on studying the methods used in the Concilium, the best possible illustration of the time-saving that such work will yield. Here he had been independently working on this question only to find the problems and methods already solved and to such perfection that he could take a new start from what had already been done.

No book index can possibly serve the purpose. In a growing science a book becomes out of date while it is going through the press. It cannot be corrected, it cannot be expanded. Alone the card system, in which each work as it appears is indexed on a separate card, will answer.

The author supposes an institution established for electrochemistry similar to the Concilium, and discusses what it will do. In some center, an office is established which works through all the technical and scientific literature of the world. In electrochemical journals, as well as in such which an electrochemist would never consult, valuable observations are found and recorded. In advance, a list of all the topics in regard to which information may be asked, is prepared, and the cards find their way to the appropriate heading, or headings—for one must consider all the applications and relations of a new fact. If there is a heading to receive references on injuries to street mains by stray electric currents, one would be astounded at the place in which valuable notes on this theme have been published. The references supplied by such an institution would be more complete than any individual effort could secure. The card index should be a printed index, so that a letter to the office calling for information on the topic mentioned, as an example, could be at once answered by sending that collection of cards. In this, the central bureau would serve as a bureau of information; but it is evident that for financial support it would depend largely upon libraries, institutions and, in a measure, industrial undertakings becoming subscribers to the whole bibliography or a considerable portion of it.

When the central office attempts to answer such a specific question as above cited, it is evident that the applicant has little interest to know by what technical method the references are picked out for him. But the purchaser of any considerable part of the index will want to know how to arrange his cards, so that he, too, can put his hand on any question that concerns him. This can be done, if a technical device can be found which will permit each subscriber to duplicate the arrangement of the cards found in the central office. For this purpose symbols are printed on the cards which show exactly where the card belongs without considering the text. The

simplest symbols are Arabic numerals and the most convenient way of using them is to arrange them as decimals, so that in the symbol 621.3, 62 is a sub-division of 6; 621 of 62, and 621.3 of 621.* Such a system permits endless expansion. As to the selection of numbers, it seems wisest to keep in touch with the most widely used system of the day, namely, the so-called decimal classification of Melvil Dewey, librarian of the New York State Library at Albany. In view of the special character of the work, this system must, however, be considerably expanded. The author is undertaking this with the aid of specialists, and the whole will ultimately be published in a key or "Conspectur."

Without, however, in any sense neglecting the theoretical aspect, it is intended that the new bibliography should be practical, for the urgent uses of the practical man. For this reason patent literature will be exhaustively treated. For so young a science as electrochemistry, it ought to be eventually possible to run back the bibliography to the beginnings of the science; but at the start the current literature should receive first attention.

Of the enormous value of such an undertaking, there can be no doubt; the question is whether it is possible to carry it out. Here it will again be necessary to say a few words in regard to the Concilium Bibliographicum. This enterprise was rendered possible by the action of the zoölogical societies of the world and by private generosity. The founder, Dr. Haviland Field, made at the start considerable financial sacrifices for the work and devoted several years to it without receiving any compensation.

At present the finances of the Concilium are such that with strict economy the staff can be paid fair salaries and the deficit is merely that covered by the annual subsidy of $1,500. The prospects are good for further improvement. Much of the expense of the Concilium consists in the maintenance of the general plant, including, as it does, a specially equipped printing office. Work done in connection with the Concilium would not only profit by nine years' experience, but would also receive the equivalent of a considerable subsidy in being able to use in part the general plant. The founding of a section of electrochemistry, in connection with the Concilium, is in accordance with the general policy of the institution. Indeed, arrangements have been made for the advance of certain funds towards the first preliminaries of such a section. These circumstances seem to decide the location of the new bureau in Zurich; but there are other reasons for such a decision. Labor is much cheaper than in America, the library facilities are excellent and are being constantly improved. Moreover, when one considers the prime function of such a bibliography, viz., that of bringing to the notice of fellow-workers matter that would have been otherwise overlooked, it is evident that to aid Americans, the best possible location is the center of Europe. What work is liable to be overlooked in America? Surely not that published in the *American Chemical Journal*, the ELECTROCHEMICAL INDUSTRY, the *Electrical World*. No, the great need is completeness of reference to work being done in less accessible places—in some hidden corner of Germany, in Russia, perchance. In this appears then the great value of such an American outpost—right in the very heart of Europe—in the little active country of Switzerland with its three national languages.

The experience of the Concilium teaches that such an undertaking ought to succeed. But all depends upon the support that members of the electrochemical fraternity can muster. The author has, therefore, taken the liberty of making a direct personal appeal to the members of the American Electrochemical Society. It would also be very desirable if they would urge the matter on friends, not members of the society, and above all would try to secure promises of probable subscriptions to the *whole* collection of cards on

* In the scheme, 6 means Applied Science; 62, Engineering; 621, Mechanical Engineering, and 621.3, Electrical Engineering.

the part of libraries and industrial enterprises. A provisional schedule of prices has been prepared which represents the maximum, it is quite three times the rate which the Concilium has introduced for its other branches. The latter low rates will be approximated, when the number of subscribers is sufficient.

The author enumerates briefly, as examples, some of the topics that might be chosen for subscription:

Complete subject cards.

Complete author cards.

Cards geographically subdivided.

Complete pure science cards.

Complete applied science cards.

The complete patent cards.

Patent cards of special countries.

Electrochemical theories and dissociation.

Mass action.

Polarization.

Electrolysis of mineral salts—pure or applied science cards.

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Primary cells.

Accumulators.

Electrometallurgy.

Electro-radiant energy.

Apparatus—experimental or industrial.

Plans and reports of plants.

Electro-therapeutics.

New books.

The address of Mr. Voege is Concilium Bibliographicum, Zurich-Neumuenster, Eidmattstr, 38, Switzerland.

GERMAN BUNSEN SOCIETY.

REPORT OF THE NINTH GENERAL MEETING IN BONN.
BY H. DANNEEL, PH. D.
(*Continued from page 277 of July issue.*)

LEAD TIN ALLOYS.

A paper on this subject was presented by Dr. O. SACKUR. The solubility of lead-tin alloys in acids is of great technical and hygienic importance. In order to study the same the author tried to determine the solution tension of these two metals by shaking one metal with a solution of a salt of the other one and determining the amount of precipitate. Preliminary experiments showed that Pb is precipitated by tin from a lead acetate solution, and that Sn is precipitated by Pb from a $SnCl_2$ solution. Other results are obtained with other solutions on account of the formation of complex ions. From a neutral lead acetate solution there is no precipitation of Pb by Sn, while precipitation takes place in the presence of acetic acid, the precipitation being the quicker the more acid is present. While under otherwise equal conditions the precipitation required two hours in a normal acetate acid solution, only one-fourth was precipitated after ninety hours in one-fourth normal acetate acid.

Tin goes into solution as stannous salt, and in time white stannous hydroxide or brown stannous oxide is formed by hydrolysis. While Pb is precipitated nearly completely by Sn in acetic acid solution, the reverse is the case in nitric acid solution, since Sn is quantitatively precipitated by Pb from slightly acidulated stannous nitrate. These facts can be explained only if one of the two metals in solution is strongly complex.

On the well justified supposition that lead and tin are very little complex in nitrate solution, lead must have the higher solution tension, since it precipitates Sn nearly completely from the nitrate solution. On the other hand, we must assume that in acetic acid solution Sn is nearly completely present in the complex form.

Experiments were made with chloride solutions containing free hydrochloric acid of different concentration, with solid lead chloride in excess. Since there are five phases, viz., solid Pb, Sn, $PbCl_2$, solution and vapor, and since the number of the independent constituents is also five, viz., Pb, Sn, $PbCl_2$, HCl and H_2O, the system has two degrees of freedom, viz., temperature and concentration of free HCl. These two quantities determine the solubility of lead chloride and the latter determines the concentration of equilibrium, provided there is no formation of an alloy; but this is improbable since the same equilibrium may be reached from both sides. The experiments were made at 18° and 25° C. It was found that after equilibrium is reached, the concentration of $SnCl_2$, and that of $PbCl_2$ (within certain limits of acid concentration) are proportional to each other, the law being

$$C_{SnCl_2} = a\, C_{PbCl_2} + b.$$

A similar equation may be derived from Nernst's formula and the two dissociation equations of each metal. The author gave the results of some experiments made to find the numerical values of the constants in the equations. He then discussed the question whether the solution tension of both metals is changed, if they are present in form of an alloy or a compound. From experiment made for this purpose, he concludes that lead in solution containing more than 11 per cent Pb, has the same solution tension as pure lead, while in alloys containing a smaller percentage of lead the solution tension of Pb decreases. In general, lead and tin do not form chemical compounds, but solid solutions (with limited solubility).

The author finally described experiments in which he measured the speed of solution of the metals and alloys in various acids. Although both metals are less noble than hydrogen, the high over-voltage on the same should not allow solution with development of hydrogen, and solution should take place rather in form of an oxidation process. Pure tin is nearly insoluble in dilute acetic acid in presence of air, while pure lead dissolves easily. This difference is undoubtedly due to a difference of the speed of oxidation, since the energy of oxidation is about the same for both metals. The speed of solution of pure lead is independent of the concentration of the acid, but increases considerably with the speed of the air current which is passed through the solution.

Since stirring is of great importance, it follows that the speed of the chemical reaction is high compared with that of the diffusion. What is really measured is not the speed of solution proper, but the speed of diffusion of oxygen. In fact, stirring with a current of pure oxygen produces solution five times quicker than a current of air.

ELECTROMETALLURGY OF IRON.

A paper on the Ruthenburg process was presented by Dr. HANS GOLDSCHMIDT, of Essen. The author described the principle of the process and the construction of the furnace (see ELECTROCHEMICAL INDUSTRY, vol. I., pages 202, 482) and gave a thermochemical calculation in which he finds (under certain suppositions) that 329 kw.-hours are required for melting 1 ton of Fe_3O_4; the figure given by Ruthenberg from measurements is 250 kw.-hours.

The report will be concluded in our next issue.

ELECTRICITY AND MATTER.—Sir OLIVER LODGE contributes to *Harper's Magazine* for August a very interesting popular article. "Electricity is not a form of energy any more than water is a form of energy. * * * Electricity cannot be manufactured, as heat can; it can only be moved from place to place, like water; and its energy must be in the form of motion or of strain. * * * What electricity itself is we do not know, but it may, perhaps, be a form or aspect of matter. So have taught for thirty years the disciples of Clerk-Maxwell. Now we can go one step farther and say matter is composed of electricity, and of nothing else." The author then gives a summary of the electronic theory and its relation to the constitution of matter.

SOLUBILITY OF GOLD IN CERTAIN OXIDIZING AGENTS.

A paper presented by Dr. Victor Lenher, of the University of Wisconsin, at the St. Louis meeting of the American Chemical Society, is quite interesting, since it shows that under certain conditions, gold is soluble in a much larger number of solutions than is generally supposed. The dissolving action of anodic oxygen in certain solutions should be of special interest to our readers.

The inactive character of gold is so pronounced that towards many of the reagents the element is quite indifferent. In fact, almost the only solvents in general use for dissolving the metal are chlorine, bromine or a solution of alkaline cyanide in presence of atmospheric oxygen. Chlorine and bromine attack the metal readily, while iodine only dissolves the metal when it is freshly liberated, or under other very favorable circumstances. The metallic perchlorides, perbromides and periodides, according to Nickles,[1] dissolve gold, the lower halides of the metal being formed along with gold chloride. Hot selenic acid readily dissolves gold. Iodic acid has slight action on the metal, while, according to Prat,[2] a mixture of iodic and sulphuric acids dissolves gold when heated to 300° C. Gold is readily soluble in a mixture of hot sulphuric and periodic acids, and also slightly soluble in the alkaline sulphides and thiosulphates.[3]

Dr. Lenher then points out that there is another class of substances—substances which evolve oxygen when treated with acids—whose action on the gold has received very little attention. He had formerly found that gold is readily attacked by pure hot selenic acid with the formation of auric selenate. In following the same line of work with telluric acid, which in many respects is closely analogous to selenic acid, the obstacle is met that the telluric acid is a solid. This difficulty can be obviated by first dissolving the crystalline telluric acid in sulphuric or phosphoric acid. Such a solution of telluric acid, when heated, dissolves metallic gold.

With the fact at hand that at the same temperature at which selenic acid or a solution of telluric acid attacks gold, the acids themselves are broken down into the dioxides and oxygen, it appeared probable that the solvent action in these cases was due to the production of oxygen in the reaction. Dr. Lenher argued that, should this view be correct, gold should be soluble in acids when an oxidizing agent is present. The action of a large number of substances, such as oxides of various types, sulphates, etc., was tried on gold in presence of sulphuric, phosphoric and arsenic acids, and only such substances as give oxygen in presence of the acids will act on gold. In most cases, the only precautions necessary in order to demonstrate the solvent action is to have the acids in a high degree of concentration.

All of the substances that have been used in the following experiments of Dr. Lenher were carefully tested for the halogens and only such substances were used as were halogen-free.

The first substance examined was manganese dioxide, as it is well-known that manganese dioxide gives oxygen when heated with sulphuric acid. A mixture of manganese dioxide and sulphuric acid, when heated for a few minutes with gold, causes the metal to go into solution. On diluting the solution and testing with oxalic acid or ferrous sulphate, all of the gold is precipitated. In working with manganese dioxide and sulphuric acid, practically the only precaution necessary is to have the acid concentrated. Solution of gold in presence of manganese dioxide and sulphuric acid takes place readily when the mixture is hot, but the reaction also takes place in the cold. A mixture of manganese dioxide and sulphuric acid, when allowed to remain in contact with gold leaf for twelve hours at 0° C., will dissolve sufficient gold to give an

appreciable precipitation, when the mixture is diluted and treated with ferrous sulphate. It is thus seen that while heat accelerates the reaction, solution nevertheless takes place at low temperatures.

The higher oxides of manganese act in an entirely similar manner. The substances actually worked with were manganese dioxide (a) native, (b) from the ignition of manganese nitrate, (c) by the action of bromine on manganese acetate: Manganese sesquioxide (Mn_2O_3), manganese proto-sesquioxide (Mn_3O_4), and potassium permanganate. The solvent action takes place in a similar manner when phosphoric or arsenic acid is substituted for sulphuric, but the action is greatly moderated.

In 1872 Allen[4] showed that when solid potassium permanganate and sulphuric acid are heated for a few minutes with precipitated gold the solution becomes nearly clear, and on diluting and testing with oxalic acid or ferrous sulphate the solution was found to contain abundance of gold. This experiment was repeated by Dr. Lenher, using sulphuric acid as described by Allen, and also by substituting phosphoric for the sulphuric acid. In all cases solution takes place and the gold can be readily detected by ferrous sulphate.

Lead dioxide, lead sesquioxide and red lead, when used with sulphuric acid, cause gold to enter into solution. The action takes place more readily in the warm than in the cold, though at the ordinary temperatures solution does actually take place, gold being found in the solution after several hours' contact.

With the higher oxides of lead, phosphoric acid can be substituted for the sulphuric acid, solution being affected. With chromium trioxide, chromium tetroxide and nickelic oxide, solution of gold is effected in presence of sulphuric or phosphoric acids, the reaction taking place, though moderated, in the cold.

When nitric acid is subjected to heat, more or less decomposition is effected, part of the acid breaking down into nitrogen dioxide and oxygen. This reaction can be used in a highly satisfactory manner to demonstrate the solubility of gold in sulphuric acid in presence of an oxidizing agent. This reaction was first noted by Reynolds,[5] and later by Spiller.[6] The results which these chemists obtained were confirmed by Dr. Lenher, and show that when a mixture of hot nitric and sulphuric acids comes in contact with gold the metal enters into solution and, at the same time, a lower oxide of nitrogen is formed by the reduction of the nitric acid and this oxide remains in the solution.

That a lower oxide of nitrogen is present in the solution after the gold has dissolved can be demonstrated in a very pretty manner, as Spiller has shown, by adding the solution to water when the metal is thrown out as a purple precipitate. Allen[7] later showed that this precipitation by water from nitric-sulphuric acid solution is due to the presence of a lower oxide of nitrogen, probably nitrous acid, since when the water used for dilution contains potassium permanganate no precipitation takes place. Also ammonium sulphate destroys the nitrous acid and, after boiling with ammonium sulphate, no precipitation takes place, while when fuming nitric acid is added to any of the liquids, the gold is thrown down, purple in color. While Reynolds, Spilier, and Allen have studied the reaction of a mixture of hot nitric and sulphuric acids on gold, the influence of temperature on the reactions seems to have escaped their attention, and also that certain other acids, as phosphoric acid, can be substituted for the sulphuric acid with practically as great solvent action taking place.

While a mixture of nitric acid with either sulphuric acid or phosphoric acid readily acts on gold when warm, solution actually takes place, though more slowly, even at zero.

The action of oxygen gas on gold leaf, suspended in hot

[1] Ann. Chim. Phys. (4), X, 318.
[2] Compt. Rend., 70, 840.
[3] Stedefelt: "Lixiviation of Silver Ores," pp. 15, 38.

[4] Chem. News, 25, 85.
[5] Ibid., 10, 48, 167, 277.
[6] Ibid., 10, 173.
[7] Chem. News, 25, 85.

sulphuric acid, was also tried, but neither oxygen nor ozone would cause any of the metal to pass into solution.

The anode oxygen, obtained in electrolysis, was next studied as to its action on gold. Bunsen noticed, when using for the electro decomposition of water an apparatus in which the platinum electrodes were connected with the terminals by means of gold solder, that on electrolyzing in presence of dilute sulphuric acid there is a film of oxide formed on the gold. Later it was shown by Spiller that when a plate of metallic gold is made the anode and a piece of platinum foil or gauze used as the cathode in an electrolyte of sulphuric acid or a mixture of nitric and sulphuric acids, the gold anode dissolves and the metal was deposited on the cathode, the source of the current used being a few Grove cells.

This work, which has been repeatedly verified, demonstrates that in presence of strong sulphuric acid, solution of gold can be effected readily by means of anode oxygen, the action proceeding rapidly when the acid is hot. On the other hand, when the acid is dilute the oxide of gold formed does not pass through the solution and deposit on the cathode as metal, but remains as an incrustation on the gold anode. Here again, a similar series of results is obtained when phosphoric acid replaces the sulphuric. When solutions of the acid sulphates of potassium or sodium are used as electrolytes, the action goes on exactly as above indicated. If the solution contains sufficient acid, gold passes through the electrolyte, while if the solution is dilute or contains only a little free acid, the oxide remains as a film on the anode.

In the case of an alkaline electrolyte, such as a solution of sodium or potassium hydroxide, it is possible for some of the gold to pass through the solution, probably from the formation of aurate of the alkali. Such is actually the case, although in alkaline solution a large amount of oxide remains as an incrustation on the gold anode employed. When neutral salt solutions are employed as electrolytes, such as the nitrates or sulphates of potassium or sodium, very little, if any, of the gold, can pass through the electrolyte, and as a result the anode is converted into the oxide Au_2O_3. Here we have the last step in the series of experiments, viz., obtaining the gold oxide in pure condition and retaining it as such.

In the above series of experiments the current used was 0.3 to 0.5 ampere at a pressure of 5 volts, the anode being a sheet of gold, and the cathode a 20-gram platinum crucible. In such experiments where gold was deposited on the crucible, the quickest method found for removing the metallic deposit, which frequently appeared as a hard plating, was found to be the hot mixture of nitric and sulphuric acids, as indicated above. This method was found to be vastly superior to that of the use of a cyanide solution, such as was at first used.

It thus appears that gold is not only attacked by the halogens, but is also readily attacked in a large number of reactions in which oxygen is produced, these latter reactions taking place readily in the warm solutions, but slowly even at as low a temperature as zero. Furthermore, it appears that it is necessary for the oxygen to be produced in the mixture and that ordinary oxygen gas, when conducted into sulphuric acid in which gold leaf is suspended, will not cause the gold to dissolve.

THE EDISON-JUNGNER CASE.

During the last weeks charges preferred by Mr. Thomas A. Edison against two examiners in the United States Patent Office, with respect to patent 738,110, granted on September 1, 1903, to Ernest W. Jungner (ELECTROCHEMICAL INDUSTRY, October, 1903, page 508), have attracted considerable attention. Mr. Edison preferred three charges. "First, that the examiners in question allowed the Jungner patent to issue when they knew or should have known that such issue was fraudulent. Second, that the examiners allowed the said patent to issue containing claims which they knew were unpatentable, and

which, in fact, they had declared to be unpatentable, and which Jungner himself had admitted were unpatentable. Third, the examiners granted the said patent for an inoperative invention, which fact had been previously brought directly to their attention and acknowledged by them."

The charges made against the two examiners were referred by the Secretary of the Interior to the Commissioners of Patents, who decided that the charges were without merit and therefore recommended that no hearing be given. Mr. Edison's counsel appealed to President Roosevelt, who decided that a full hearing be given to Mr. Edison. The Commissioner of Patents referred the matter to his assistant, Mr. Moore, before whom the argument was made.

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THOMAS A. EDISON.

The main point made was that Jungner bases his case on an application for a patent filed in the spring of 1899; that he tried two years afterwards by amendment to include certain chemical and mechanical features; that this was not permitted by the Patent Office on the ground that the amendments embodied new matter; that in June, 1902, Jungner filed an application for a patent which was represented as being a division of his original application of 1899; but this divisional application contained the same features of "new matter" which he had been unable to embody in his original patent by way of amendment. In his report on the hearing, addressed to the Secretary of the Interior, the Assistant Commissioner says that "the disclosure in the Jungner patent is a different invention from that originally disclosed by him in his parent application, and therefore there is no basis in the original disclosure for the disclosure of his patent, and that therefore, the examiners erred in allowing the Jungner patent as a division of the earlier application, as the patent is not in fact a division, for the reason that it not only contains new descriptive matter relating to its mechanical structure, but the invention disclosed is so changed as to be, in fact, another invention from those originally disclosed in the early application and that the patent therefore as to this new matter is effective only as to its new filing date." Thus, the two examiners were found to have erred, though there was absolutely no evidence of malfeasance or intentional wrong-doing. They were relieved from their present assignment and transferred to another examining division of the Patent Office.

E. W. JUNGNER AND M. U. SCHOOP.

*   *   *   *

The adjoining portrait of Mr. T. A. Edison, with the incandescent lamp was recently taken in connection with the twenty-fifth anniversary of his invention of the lamp. For the por-

trait of Dr. E. W. Jungner and Mr. M. U. Schoop we are obliged to the latter gentleman. The picture was recently taken in Norrkoeping, Sweden, where the Jungner-Accumulator Aktiebolaget has a plant. Mr. Schoop is the chief engineer of the German storage battery concern which has bought Dr. Jungner's German patents, and is the author of the able paper on the oxygen-lift cell which is concluded on another page of this issue.

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According to a note published in the *Elektrotechnische Zeitschrift* of July 21, the Jungner Co. has installed three automobiles for passenger traffic between Norrkoeping and Kneippbaden in Sweden. The present Jungner accumulator is said to differ little from the Edison cell. The active masses of nickel and iron hydroxides, mixed with graphite, are placed in pockets under strong pressure. "Jungner makes the units considerably greater than Edison, eight unit-pockets being combined in one electrode. The thickness of the plate is 3.5 mm. for the positive electrode and 2.5 mm. for the negative electrode. The distance between the plates is 2 mm. Chemically pure 20 per cent potassium hydroxide solution is used as electrolyte." An article by Schoop, giving historical notes on Jungner's work, was abstracted on page 289 of our July issue.

It is stated that Jungner is now renewing his former experiments with the silver-cadmium battery with which he is said to be able to get fifty or more watt-hours per kg. of total cell.

SYNOPSIS OF ARTICLES IN OTHER JOURNALS

A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

INDUSTRIAL ELECTROCHEMISTRY.

Electrolytic Treatment of Zinc Sulphides.—In our August issue, 1903, page 412, we described the Swinburne-Ashcroft process for treating complex sulphide ores; the last step of this process is the electrolysis of fused zinc chloride. In the *Engineering and Mining Journal*, June 2, C. A. BURLEIGH gives some interesting results obtained by electrolysis of aqueous solutions. Various ores were treated by an alkaline solution which was electrolyzed, and the lead plated out completely, after which, in another set of cells, the most of the zinc was plated out and the solution returned to fresh ore, where it was again enriched by lead and zinc dissolved from the fresh ore; care being taken that a large enough amount of solution was used so that all the zinc and lead in the ore could go into the solution without saturating it. The voltage used in the lead cells varied from 1.5 volts to 1.7 or 1.8 volts per cell, depending upon the degree of concentration of the solution, also upon the percentage of lead in solution and number of amperes per square foot of cathode surface. Chiefly, although some other factors may, and frequently do, cause some slight variations, the first cells always show the lowest voltage. A fair general average of the voltage in the lead cells would be 1.6 volts per cell, using 130 to 140 ampere-hours to deposit a pound of lead. In the zinc cells the voltage may be made to vary within very wide limits; good work may be done from 2.25 to 5.6 or even 7 volts per cell, using a varying amperage of from 8 to even 200 amperes per square foot of cathode surface. With properly constructed cathodes 400 to 425 ampere-hours sufficed to produce a pound of zinc. As 375 ampere-hours are what theory calls for, the commercial ampere-hour efficiency falls between 88 to 93 per cent. While variations in the strength of solution, per cent of zinc carried and position of the cell in the series do cause differences of voltage, the number of amperes used per square foot of cathode surface is the great controlling factor; any increase in the number of amperes used increases the voltage. Equally good work can be obtained by using 2.2 volts up to 6 volts per cell, so far as the quality of the metal is concerned; it is deposited, hard, smooth and dense and of high tensile strength at any voltage within these limits. It is purely a commercial question whether to use 2.25 volts and 8 or 10 amperes per square foot, or 3 to 3.5 volts and about 30 amperes per square foot, or even a higher amperage per square foot of cathode surface. A higher efficiency requires a relatively larger plant per pound of zinc produced than a lower. Sometimes it is good policy to force the cells to do double the work and produce double the number of pounds of zinc per day, even if it does cost a little more current for each pound of zinc produced. As equally good results have been obtained from ores varying from 12 to 59 per cent of zinc and 4 to 20 per cent lead, the value of the metals left in the tailings will frequently control the easily regulated efficiency of the zinc plant. With high values in, for example, gold, silver and copper, and with plenty of smelter capacity and also of ore, it might be true economy to use a high voltage and get off the greatest tonnage possible. After several continuous runs, some five or six months long, the solution, although several different ores were treated, some containing arsenic and manganese, was not vitiated.

Ferro-Silicon.—The June issue of *L'Industrie Electrochimique* contains an article on the manufacture of ferro-silicon, with references to a paper by Keller on this subject. The fact which has brought the electric furnace to the front in this line of work is the ease of producing a ferro-silicon, containing a high content of silicon, from 25 to 80 per cent. (The advantages, resulting from this fact, were pointed out in an article in our March issue, 1904, page 122.) The electric furnace manufacture of ferro-silicon can be economically carried on only in large plants with powerful electric furnaces. The starting materials should be quartz, scrap iron and coke. Quartz is preferable to sand, since the latter is able to clog the furnace. Iron and steel scrap is preferable to iron ore, since, with pure quartz, the operation is "slagless." The purity of the ferro-silicon produced depends on the care taken in the operation.

Electrometallurgy of Iron and Steel.—In a paper read before the Canadian Society of Civil Engineers and abstracted in the *London Elec. Rev.*, of June 24, A. STANSFIELD discusses the possibilities of the various electric furnace processes for the preparation or refining of iron and steel. Relying on a large number of figures, he holds that electrical energy can be bought in Canada on a large scale at the price of about 0.15 cent per hp.-hour or 0.20 cent per kw.-hour. If, then, the reduction of one metric ton of pig iron from ore requires 2500 kw.-hours, the cost of energy comes to $5.00 Against this may be set the price of fuel saved by using electric heat. This is about 0.6 ton of coke which, at $2.50 per ton, is equal to $1.50 per ton of iron. Thus, electric smelting of such ores as are capable of treatment in the blast furnace cannot compete with the latter, even where very cheap water power is available, unless the price of coke is $8.00 per ton. There are, however, certain ores, such as iron sands and titaniferous ores which can only be treated with difficulty in the blast furnace; for these the absence of the blast and the higher attainable temperature may render the electric furnace more useful. Moreover, refractory ores exist which can only be treated at all if they prove suitable for reduction in the electric furnace. Probably the greatest field of usefulness of the electric furnace, however, will be found in the production of crucible steel. He thinks that the electric manufacture of crucible steel is technically and financially possible in Canada; the

energy might be developed from water power or by gas engines fed by blast furnace gas.

In *Stahl und Eisen*, June 15 and July 1, B. NEUMANN begins a long critical review of the various processes which have been proposed for the application of the electric furnace to the iron and steel industry. He begins with the process of Ruthenburg and then passes over to a discussion of the various processes in which furnaces with carbon electrodes are used. The following furnaces are described: Siemens, De Laval, Stassano, Conley, Heroult, Keller, Harmet. He then passes over to the description of processes in which no carbon electrodes are used and describes the furnaces of Kjellin, Gin and Girod. The article is to be continued.

Electrolytic Iron.—The great interest which has been aroused by Burgess and Hambuechen's recent paper on the electrolytic refining of iron (ELECTROCHEMICAL INDUSTRY, May 1904, page 184) is shown by two notes published in foreign journals. W. W. H. GEE states in the London *Electrician*, June 24, that he made some experiments on the electrodeposition of iron fifteen years ago, wishing to deposit rings of pure iron for the purpose of determining the permeability by the method of Rowland. The solution with which he obtained his best results was the same which Burgess and Hambuechen advise—*i. e.*, one containing sulphates of iron and ammonium. He obtained fine deposits of iron on flat rings of copper, but was unable to get any considerable thickness. One difficulty which he encountered, was the oxidation of the solution and the electrodes; to obviate this he fitted up an arrangement for carrying on the electrolysis in an atmosphere of hydrogen.

In the *Elektrochemische Zeit.*, July, A. NEUBURGER writes that in 1890 he and N. von Klobukow made experiments on the deposition and separation of iron by electrolysis for analytical purposes. They found that under certain conditions, iron can be deposited in quantitative amounts up to one gram; with greater amounts the deposition is no longer quantitative, but if the conditions of analysis are maintained with some modifications, the iron can be deposited in large quantities and in very good form. They thus produced a half sphere and a total sphere with a wall of one cm. thickness. The purity of their iron was 99.9 per cent. They did not observe any contents of hydrogen in the iron. They found that their electrolytic iron would not rust, even though they endeavored to make it rust. Their method was as follows: They used a solution of crystalized ferrous sulphate in water, carefully neutralized with ammonia; in case of any excess of ammonia, oxalic acid was added. A considerable amount of ammonium oxalate was added to the solution. The current density was one ampere per square decimeter, the voltage being in the average about 3.5 volts. During electrolysis, brown iron carbonate was some times precipitated, which could be dissolved by an addition of oxalic acid. The precipitate adhered very firmly and was difficult to remove in all cases.

Refining of Silver.—An article on the electrometallurgy of silver refining is published in *L'Industrie Electrochimique*, June. If a dilute silver nitrate solution is electrolyzed with a silver plate containing gold as anode, silver dissolves and is deposited on the cathode, while the gold remains in the anode slime. If the anode sludge is boiled with nitric acid the small quantities of silver still contained in it are removed and gold of a purity of 0.999 may be obtained. Some details are given on the process of the St. Louis Smelting and Refining Co., and on some other plants.

Electrolyzer for Copper Refining.—D. TOMMASI describes a somewhat peculiar apparatus for copper refining in *L'Electricien*, June 25. A rectangular tank contains a solution of acidulated copper sulphate to which are added certain "dopes" to cause a compact deposit of the copper and to reduce the resistance of the electrolyte. Between two copper anodes the cathode is placed, consisting of a disc formed of a number of metallic segments on which the copper is deposited, while the

disc is revolved at a speed of 80 to 100 revolutions per minute, with a current density of 1 to 2 amperes per square decimeter. When the copper deposit is sufficiently thick, the segments are removed, without interrupting the operation.

Bismuth.—In *L'Industrie Electrochimique*, June, H. BECKER gives a review of the electrometallury of bismuth. No electrolytic or electrothermic processes have been proposed for the extraction of bismuth from its minerals and the prospects of the application for such methods are poor, since bismuth minerals are found in districts where they must be worked by a process of little complication and without expensive installations. For the winning of bismuth from raw lead, Borchers has described a process which is discussed in some detail. It consists essentially in the electrolysis of fused alkaline chlorides in contact with raw lead as anode. Lead dissolves and is deposited on the cathode, while bismuth and silver remain undissolved. It does not seem that his process has ever been employed on an industrial scale.

Electrolytic Oxygen and Hydrogen.—The problem of producing oxygen and hydrogen by electrolysis of an acid or caustic solution resolves itself into preventing the oxygen and hydrogen gases which are generated at the anode and cathode, respectively, from mixing. In the Hazard-Flamand process, which is described in the *Electrochem. and Met.*, June, from a report of Prof. Dalby, the anode and cathode are kept separated from each other by means of insulating partitions which of course do not fill the whole cross-section of the cell; their peculiar mechanical construction is the novel feature of the apparatus. The corrugated inside walls of the box A, and of
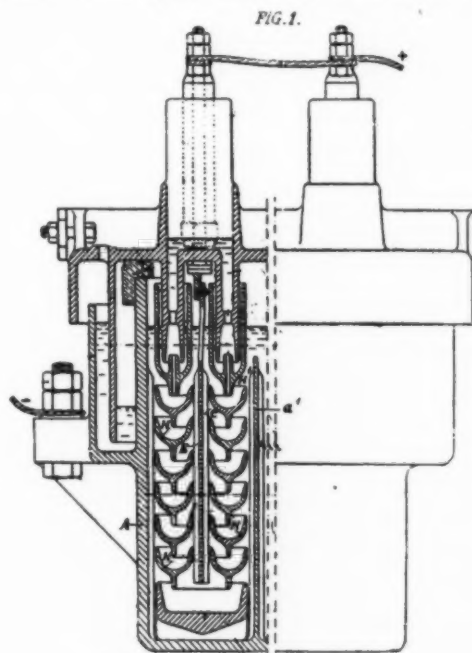

FIG. 1.—ELECTROLYTIC PRODUCTION OF HYDROGEN AND OXYGEN.

the transverse partitions a^1 form the cathode, while in the center of each chamber, thus formed, the anode E is placed. The insulating partitions which keep the anodic oxygen separated from the cathodic hydrogen are provided in the form of gutters H, of Y cross-section, made of ebonite, porcelain or glass. The construction is shown in Fig. 1, and it will be seen that the electrolyte has a clear passage from the anode to the cathode, while the construction of the gutters H is stated to prevent the gases from mixing so effectively that the oxygen is 99 per cent pure. The electrolyte used is a solution of 15 per cent caustic soda and distilled water. If 2.1 volts are ap-

plied at the voltameter terminals the yield of oxygen per kw.-hour is 141.7 grams, giving a watt-hour efficiency of 66.5 per cent. For 2.8 volts the yield of oxygen is 106.3 grams per kw.-hour, the watt-hour efficiency being 50 per cent. A plant using this process is situated near Paris.

THEORETICAL AND EXPERIMENTAL.

Electrolysis of Acid Sodium and Calcium Sulphites.—In the *Zeit. f. Elektrochemie*, July 8, A. R. FRANK describes some experiments in which he electrolyzed acid sodium and calcium sulphites in the following apparatus: A large porous cup contained the platinum cathode and was filled with the sulphite solutions. It was itself placed in a glass vessel containing sodium chloride or sodium hydroxide or sulphuric acid solutions with corresponding anodes. With acid sodium sulphite, in the cathode compartment it was easy to get $Na_2S_2O_4$, but after some time this began to become decomposed. Nevertheless a good ampere-hour efficiency can be obtained for some time if special precautions are taken. It is especially important to use neutral solutions. He succeeded in obtaining solutions containing 30 to 40 grams $Na_2S_2O_4$ per liter, when starting from solutions that contain 5 per cent SO_2. With $CaH_2S_2O_6$ in the cathodic compartment (containing originally 40 to 60 grams SO_2 per liter) he could produce for some time CaS_2O_4 solution with an ampere-hour efficiency of 60 to 70 per cent.

Copper Anodes.—If a copper plate is used as anode in an electrolyte which allows the formation of a soluble copper salt, the supposition generally held is that the copper goes into solution with formation of this salt. Under certain conditions, however, a peculiar phenomenon is observed. Two copper wires are suspended in sulphuric acid of maximum conductivity; they may be 1 mm. thick and suspended into the electrolyte 10 mm. deep; if now an e. m. f. of 20 volts is applied at the two wires, the anode wire is pulverized, giving off dense clouds of a dark dust which remains suspended in the electrolyte for a long while, the dust consisting of metallic copper; simultaneously cupric sulphate is formed in the electrolyte. If the e. m. f. of 20 volts is not applied immediately, but the voltage at the two wires is raised gradually, it will be observed that the pulverization of the copper anode is preceeded by a condition which is quite analogous to the electrolytic valve action of the aluminium anode. When the e. m. f. is then gradually raised, the pulverization of the anode takes place as soon as the condition of the anode which counteracts the passage of the current is overcome. Starting from these phenomena, F. FISCHER has studied in detail what takes place on the copper anode, an account of his results being given in the *Zeit. f. Elektrochemie*, June 24. He remarks that the formation of copper dust on copper anodes in sulphuric acid is nothing essentially new; it is, for instance, observed in copper voltameters in which, with the usual current density, the anode is not dissolved completely to $CuSO_4$, but there is always simultaneously a precipitation of dark dust on the anode which was before absolutely bright. This dust is now known to be copper which is produced from primarily formed cuprous sulphate according to the ionic reaction $2Cu\cdot \rightleftharpoons Cu + Cu\cdot\cdot$. The main results of Fischer's investigations are as follows. When the current density is gradually being increased at a copper anode in sulphuric acid, a transition resistance is produced caused by the deposition of a solid salt, as soon as the speed of formation of the salt is greater than the speed of its solution. If the current is maintained constant, the current density then increases, and with it the e. m. f. at the terminals. As long as the anode does not get hot, oxygen is produced together with cupric sulphate. When the temperature of the anode rises, the formation of oxygen stops, and, besides cupric sulphate, increasing quantities of cuprous sulphate are produced. If the temperature in the pores rises up to the boiling point of the electrolyte, the anode is pulverized with a singing noise, clouds

of very fine copper dust being formed. What happens is that the steam blows the mixture of cupric and cuprous sulphate (formed at the copper anode) into the cold electrolyte, where the cuprous sulphate (which had been formed at high temperature) is decomposed into copper dust and cupric sulphate. The ratio of the quantity of copper dust to the simultaneously formed quantity of cupric sulphate increases with the concentration of the sulphuric acid, that is, with the temperature in the pores causing pulverization (which is equal to the boiling point). Up to 50 per cent of anodic copper may be dissolved primarily as cuprous sulphate. A result of the formation of copper dust is the fact that at a copper anode at high-current density, chromic acid and the like are reduced.

Stirring During Electrolysis.—For various purposes of electrolysis—in industrial operation as well as for analytical purposes—the great importance of strong agitation of the electrolyte has long been recognized, but its importance has been recently emphasized in some special cases and it seems that some people were surprised at the effect produced by stirring. In an article published in *Zeit. f. Elektrochemie*, July 8, H. SAND points out that there is nothing mysterious in the effect of stirring. It seems not doubtful that the current density which is permissible for electrolyzing a certain solution depends upon nothing else but the speed with which the layer of the electrolyte next to the electrode is replaced by fresh solution. For depositing metal, the cathode potential is independent of the current density, and the condition of the metallic deposit depends to a very small degree only on the current density—as long as the layer of electrolyte next the cathode remains the same. The great differences which are observed in practice with various current densities, result from nothing but local concentration changes. If there was no diffusion, continuous electrolysis·would be impossible, since otherwise the concentration of the metal ions near the cathode would instantaneously decrease to zero. Diffusion must also be supplemented by convection currents in order to destroy concentration differences. He gives a formula for the time in which the concentration at the electrode would decrease to a given fraction if there was no convection or artificial stirring. He makes a few remarks on plating on articles which have non-uniform surfaces, containing holes, etc. The conditions which are favorable to high-speed electrolysis, are unfavorable to good "straying" of the lines of current (as required for plating the inside of holes, etc.), but this does not prevent the production of coherent metallic deposits during high-speed electrolysis.

Very Small Ionic Concentrations and the Atomic Theory.—The beauty of the electrolytic dissociation theory rests to a large degree on the simplicity and conciseness of its propositions, and on the relative ease with which it has been possible to work it out mathematically. It is not surprising that in working out detailed results and following up all consequences of the theory, some times discrepancies between facts and theories were found, and in other cases the theory led to results which, while not directly wrong, yet offered difficulties to the conception. Among the latter were the extremely small ionic concentrations which have some times been calculated as results of measured e. m. f.'s and Nernst's theory of solution tension. Ostwald once found by such a method that one cc of a solution with which he worked should contain only two silver ions. If the volume of one cc was then divided into three portions, at least one of them would contain no silver ion. Ostwald tried to get out of his difficulty by pointing out that an individual silver ion which exists in solution is not necessarily an ion all the time. Any silver atom which exists in the solution in form of the complex ion $Ag(CN)_2$, can and will become a silver ion for some time, and the figure for the ionic concentration really gives the time for which a silver ion can exist as such compared with the time for which it exists as part of the complex ion. In a short but interesting paper in the *Zeit f. Elektrochemie*, July 1, F. HABER criti-

cises this view and points out that in such changes electric charges are involved, and that such a change cannot be quicker than electric changes in general. Electric impulses are propagated with the speed of light. From this figure we can arrive at a minimum time which we are justified to assume in the formation of complex ions. Haber finds that the theory here gets into difficulties which have not yet been solved. He reaches the result that the reality of the extremely small concentrations which are calculated from e. m. f's. in complex solutions, is a somewhat arbitrary assumption. On the basis of the atomic theory, it is difficult to imagine ionic concentrations smaller than the OH' concentration in one ion-normal sulphuric acid, and it seems impossible to imagine such small concentrations as have been calculated in the above example of the silver ion.

GENERAL METALLURGY AND MISCELLANEOUS.

The Behavior of Several Metals in Sea-Water has been studied by twelve-month tests, in the harbor of Kiel, by Engineer DIEGEL, and reported *in extenso* in *Stahl und Eisen* of May 15 and June 1, 1904. Particularly interesting for electrochemists is the behavior of different metals in contact with each other, and moistened by sea-water. Thus, for two irons containing different percentages of phosphorus, of equal surface and in contact with each other, the iron with 0.01 per cent phosphorus was always the anode, and was corroded three to six times as fast as iron with 0.09 to 1.08 per cent of phosphorus. Regarding the corrosion of nickel steel, isolated and insulated plates showed losses by corrosion corresponding to 6 milligrams per square decimeter per year for no nickel, 4 milligrams for 6 per cent nickel, and thence decreasing linearly to 1.6 milligrams for 30 per cent nickel. When two steels with different nickel contents were in contact with each other, the higher nickel alloy acted as cathode and was practically untouched during twelve months' immersion, but the lower nickel steel was corroded two to ten times as much as it was when insulated and alone. The potential difference between these steels increased as the content of nickel increased, the lower nickel alloy being the anode. As practical results of these observations are the recommendations that steel parts of boilers and ships' hulls should be made with a uniform content of phosphorus and of nickel. If a particular part of a boiler is strongly corroded, such as the tube, it will be of advantage to make it of higher phosphorus than the rest of the boiler. Where nickel steel is used in ships in contact with nickel-free steel or iron, the nickel should be kept to as low a per cent as possible, to avoid excessive corrosion of the nickel-free parts. With 6 per cent nickel steel, it is practically untouched, while the nickel-free parts in contact with it are corroded 50 per cent faster than when insulated and alone. If a certain part of a steel or iron body immersed in salt water needs particular protection or preservation, and is not very large in comparison with the whole body, it will be untouched if made of a high nickel steel—30 per cent is recommended. If the 30 per cent nickel steel is used, however, in combination with copper or bronze, it (the steel) will act as anode in this case, and be very strongly corroded.

Regenerative Gas Furnaces.—A circular of the Friedr. Siemens Company apprises us of the large field already occupied by the new form of regenerative gas furnace, which may be new to some of our readers. Since over 1000 of these furnaces are now in operation, mostly for melting small charges up to 10 tons, and have been found most economical, their use may certainly be regarded as a permanent advance in the metallurgical art.

The gas producer is united with the furnace in one structure; as in the well-known Bicheroux furnace, but the gases, passing into the rectangular melting chamber, pass in alternately at one end and the other, passing thence through regenerators into the chimney. The regenerator, which is not being heated, is used for heating the air supply which burns the gas at its entrance into the furnace. If the producer runs too hot, part of the chimney gases may be diverted into it, the carbonic acid of which is converted into carbonic oxide in the producer and thus redevelops heat in the furnace. A ten-ton steel furnace is claimed to cast only 60 per cent of the cost of an old-type Siemens furnace, the space occupied to be a trifle over half, and the fuel consumption only 300 kilos per ton of steel, as against 500 kilos in the older type of furnace. For foundry use, it is claimed that it will replace an ordinary reverberatory furnace to such good effect as to save its cost within a year.

High-Speed Tool Steels is as fascinating a subject to the scientific metallurgist as it is important to the machinist. To find a steel of such composition that, by peculiar and appropriate treatment, it will retain cutting hardness at a low-red heat, is a problem which has recently been solved in a most satisfactory manner, and which has been at once utilized industrially. In the *Revue de Metallurgie* for May, 1904, L. GUILLET discusses at length the properties of tungsten steels, and in the same journal for June, 1904, is an article by Prof. H. LE CHATELIER on high-speed tool steels.

Guillet comes to the conclusion, by applying Frémont's system of studying resistance to shock, that there is a critical point in the content of tungsten, viz., 5 to 7 per cent, below which these steels have the same structure as simple carbon steels, their strength and hardness increases proportionately to their tungsten content, and their fragility is sensibly unaltered; above this tungsten content they have a high tensile strength, low elastic limit, small elongation and reduction of area, and are of great fragility, but their hardness is great and increases with their carbon content. Under the microscope, when tempered, the first class shows pearlite, like ordinary steel, the second class, hardened from 850°, shows extremely fine martensite, *i. e.*, uniformly distributed carbide, with some carbide undissolved. Steels in which the tungsten is more than six times 1.6 per cent less the carbon content belong to the second class, where the tungsten is less than this, to the first class. The second class, of course, are the high-speed steels.

Prof. Le Chatelier discusses the experiments and patents of Messrs. Taylor and White, of the Bethlehem Steel Co., saying that when, in 1900, the news spread in Paris that at the annex in Vincennes an American firm was cutting off enormous turnings of iron with a tool which was red-hot at the point while cutting, every one smiled at the report, regarding it as a "Yankee bluff" until they had seen the thing with their own eyes. In his article, Le Chatelier explains very clearly how the presence of the tungsten raises abnormally the temperature at which the tempering or softening of the steel takes place, and that this temperature is also dependent on the temperature from which the tungsten steel has been hardened. The recent improvements in these steels have been to increase the tungsten up to as much as 20 per cent, chromium being usually present from 1.5 to 8 per cent, and to avoid excessive hardness or brittleness by reducing the carbon below 1 per cent, usually to 0.5 or 0.7 per cent. Prof. Le Chatelier supports this statement by seven analyses recently made by himself, all falling within these limits, but in which, according to his own statement "le molybdène n' a pas été dosé." If he had looked for and determined the molybdenum, he would have found, to his surprise, that the most recent high-speed steels contain not such quantity of molybdenum as may be ignored in an analysis, but 4, 6 and even up to 10 per cent of molybdenum, the tungsten being largely diminished. In this manner, a steel is obtained with less percentage of hardening elements, and not so apt to crack in hardening. America took the lead in high-speed tool steel, by Messrs. Taylor and White's invention, but it is keeping at the front by the judicious use of high percentages of molybdenum, a fact which Prof. Le Chatelier might have discussed had he "determined the molybdenum" in the specimens which he analyzed.

Theory of the Blast Furnace Process.—In a paper by R. Schenck, published in the *Zeit. f Elektrochemie*, June 10, the author refers to the composition of the blast furnace gases; as an average he gives the following composition:

N 54 to 66 per cent.
CO_2 7 to 19 per cent.
CO 21 to 31 per cent.
H_2 1 to 6 per cent.
Hydrocarbons 0 to 6 per cent.

The average proportion of CO to CO_2 varies between 2.44 and 1.04. The author discusses the conditions on which this ratio depends. The reaction $FeO + CO \rightleftharpoons Fe + CO_2$ is reversible and is not complete, and an equilibrium is reached when the reaction of the above equation going from the left to the right hand occurs with the same speed as the reverse reaction (from the right to the left hand). Baur and Glaessner started once with FeO and CO, and in other experiments with Fe and CO_2. The analysis of the resulting mixture of gases gave exactly the same composition in both cases. This equilibrium is independent of the atmospheric pressure, but depends on the temperature as is shown in the following table:

Temperature Degrees Centigrade.	Contents in Gas Mixture.	
	Per cent CO.	Per cent CO_2.
550	64	36
680	59	41
750	61	39
900	71.5	28.5

The minimum content of CO is therefore obtained at a temperature of 680° C., this corresponding to the ratio CO to $CO_2 = 1.44$. But this refers only to the one reaction between FeO and CO. In reality the ores contain mainly the oxides Fe_2O_3 and Fe_3O_4, and the situation is much more complex. For the reversible reaction $Fe_3O_4 + CO = 3FeO + CO_2$ he gives the following table, showing the composition of the gas mixture in the state of equilibrium at various temperatures:

Temperature Degrees Centigrade.	Contents in Gas Mixture.	
	Per cent CO.	Per cent CO_2.
450	46	54
490	47	53
550	44	56
750	30.5	69.5
950	23	77

The ratio of CO to CO_2 has a maximum (0.887) at 490° C. In producing spiegel iron and ferromanganese, ores containing manganese are brought into the blast furnace; manganese is less noble than iron; the blast furnace gases will be in this case especially rich in CO. This shows that the composition of the blast furnace gases depends as well on the nature of the ores as on the temperature in the furnace. But the reduction of oxides by means of CO is not the only process which can take place in the blast furnace; sometimes the deposition of very finely divided carbon is observed. This is due to the reaction $2CO = C + CO_2$, which is also reversible. This reaction requires a catalytic agent; the author has studied this reaction first with nickel and cobalt as catalyzer, and later with iron. The results are given in forms of diagrams and tables.

Protection of Iron and Steel From Corrosion.—For preventing iron and steel from rusting, it is often coated with zinc, "hot galvanizing" being the method most extensively used. Electroplating with zinc is in use for special classes of work, and is extensively employed by the British admiralty for giving boiler tubes a thin flashing of zinc for the purpose of detecting flaws and protecting the tubes from corrosion during the time of assembling and erection. Sherard Cowper-Coles describes in the *Electrochem. and Met.*, June, a new process which is called "sherardizing." The first step is to free the iron from scale and oxide by dipping it in an acid solution, or by sand blasting. The articles are then placed in a closed iron receptacle, charged with zinc dust, which is heated to a temperature from 500° to 600° F. for a few hours and allowed to cool; the drum is then opened and the iron articles removed, when they are found to be coated with a fine homogeneous covering of zinc, the thickness of which depends on the temperature and the length of time. It will be observed that the temperature required to bring about this result is about 200° below the melting point of zinc. The low temperature required makes the process cheap, as compared with the process of dipping in molten zinc, and has the additional advantage that it does not deteriorate iron and steel of small section to the same extent as hot galvanizing. The whole of the zinc dust is consumed; there is no waste of zinc as in the hot galvanizing process. The zinc powder used is commercial zinc dust and should not be confused with zinc oxide; it is obtained during the process of distilling zinc from its ores. The receptacle in which the process is carried on is air-tight and the air exhausted so as to prevent the formation of too much zinc oxide; to prevent the iron receptacle from becoming coated with zinc, its inside is coated with plumbago or black lead. Articles coated with grease receive as good if not a better coating of zinc than those which are free from grease. The equipment of works for carrying out this process is described and illustrated.

Distillation of Zinc is a topic recently made the subject of exact thermo-electric temperature measurements by W. McA. Johnson (this journal, May, 1904, page 185), and also the subject of an interesting article in *Thonindustrie Zeitung* (1904, page 154). We take the following facts from an abstract in the *Revue de Metallurgie*, June, 1904. The temperature outside of the retorts, in the furnace, varies between 1067° and 1320° C.; the temperature of the charge rises in two hours to 814°, in eight hours to 1000°, where it remains constant for some time. This period of constancy corresponds to the period of rapid evolution of zinc, and is caused by the great absorption of heat in that reaction. Towards the end of the distillation, the temperature inside the retort rises to 1180° C. The losses of zinc amount to an average of 3 per cent in the residues, 1 per cent escaping through the condenser, 2 to 3 per cent escaping through the walls of the retort and a variable amount is absorbed by the retort itself. The latter loss may amount to 26 per cent of the zinc in the charge, for a fresh retort, and diminish to nothing at the end of seven or ten days, at the end of which time the clay of the retort has been entirely converted into zinc aluminate, while the silica remains in it as tridymite, in flat hexagonal crystals. The change of color of the retort material to a bright blue coincide with this transformation into aluminate.

LOCAL BRANCHES OF NATIONAL SOCIETIES.

A recent report of the Committee on Local Organizations of the American Institute of Electrical Engineers shows that there are twenty-nine branches of the Institute, in as many different cities. The average total attendance at these branches is stated to be over 1,300, while the attendance at the New York meetings of the central organization is not over 200. Consequently, through its branches, the Institute has increased its attendance at meetings, for the consideration and discussion of papers, more than six-fold. This result is especially gratifying, since it first was doubted whether the organization of local branches would have any other good effect, except the increase of membership. The latter result has indeed been accomplished to a remarkable degree.

The American Electrochemical Society has three local branches in New York, Philadelphia, and Madison, Wis. The meetings of these local branches were duly recorded in our columns. A report of the first meeting of the New York Section, with papers and discussions in full, may be found in the recently issued volume V. of the Transactions of the Society.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

BY GEORGE P. SCHOLL, PH. D.

ELECTRIC FURNACE AND FURNACE PRODUCTS.

Electric Furnace.—C. P. E. Schneider, Le Creusot, France. Patent 763,330, June 21, 1904. Application filed December 22, 1903.

The furnace is a combination of the electric induction furnace and the electric melting furnace, for the purpose of melting the metal under treatment in the furnace itself, thus doing away with the necessity of a preliminary fusion of the metal in another vessel, as required in the inventor's former induction furnace, described in the July issue, 1904, p. 283. A longitudinal cross-section of the furnace is given in Fig. 1. It consists of a chamber *a*, which serves as a reservoir for the major portion of the metal. That part of the furnace in which the metal is to be heated by induction is constituted by a tube of
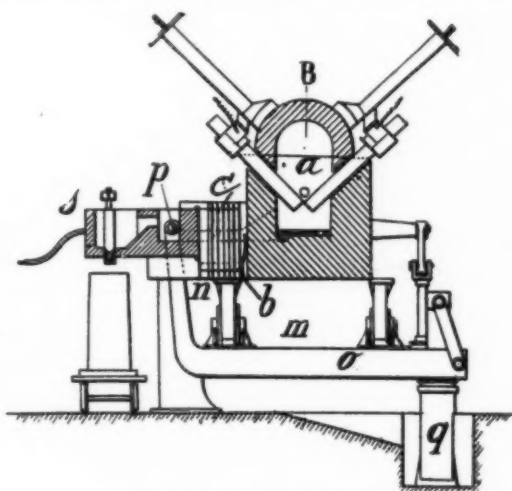

FIG. 1.—STEEL FURNACE.

small cross-section, both ends of which communicate with the chamber *a*. The heating of the metal in the tube is accomplished by two transformers *cc*, consisting of a magnetic circuit and a primary, while the tubes *b*, together with *a*, form the secondary. Two or more pairs of electrodes are introduced into the upper part of the chamber, so that they may be lowered, and the arc is struck either between the electrodes and the bath, or between the electrodes themselves. The furnace is supported on a movable platform and travels on rollers *m* by means of segments *n*. The rollers *m* are carried in their turn by a frame *o*, which rocks about the pivots *p*, the motion being produced by two hydraulic cylinders *q* and *r*. The tapping is done by means of a tapping way *s*, with spindle and plug, which communicates with the heating tube *b*.

Process of Electrolytic Manufacture of Aluminium.—Gustave Gin, Paris, France. Patent 763,479, June 28, 1904. Application filed May 14, 1903.

The process consists essentially in the electrolysis of a mixture of aluminium fluoride and sodium sulphide according to the formula $Al_2F_3 + 3Na_2S$, at a temperature of about 850° C. It is claimed that as soon as the mixture begins to melt, the constituents react upon each other with the production of sodium fluoride and aluminium sulphide, according to the formula $2(Al_2F_6 + 3Na_2S) = (Al_2F_6, 6NaF) + (Al_2S_3, 3Na_2S)$. The sulpho-aluminate $Al_2S_3, 3Na_2S$ has a much lower

heat of formation than the other salt, and is stated to be alone decomposed by the current, the aluminium going to the cathode and the sulphur to the anode, while the sodium sulphide reacts upon the fluo-aluminate to furnish a new quantity of aluminium sulphide. The reaction in the latter case is given as: $(Al_2F_6, 6NaF) + 3Na_2S = Al_2S_3 + 12NaF$. Electrolysis is carried out with direct current of five to six volts and a current density of one ampere maximum per sq. cm. of active surface of the carbon anodes, and 2.5 amperes minimum per sq. cm. of cathode. The preparation of the electrolyte and the utilization of the various products resulting from the intermediary steps are intended to form a sort of continuous closed cycle. The raw material for the process is bauxide, which is dried, but not calcined, pulverized and subjected to the influence of a solution of hydrofluoric acid. The latter converts the constituents of the bauxite into aluminium fluoride, iron fluoride and aluminium fluosilicate and fluotitanate, from which solution the iron, silica and titanic acid are removed by adding hydrated alumina, the reaction being accelerated by being carried out at a temperature of about 60° C. The sulphur vapor disengaged at the anode is proposed to be burned in contact with the air and the resulting sulphurous acid transformed into sulphuric acid, either by the lead chamber or the contact process. This sulphuric acid is then utilized for obtaining hydrofluoric acid from the sodium fluoride, the reaction being $H_2SO_4 + NaF = Na_2SO_4 + 2HF$. This operation takes place in an apparatus, the sides of which are lined with bricks made of barium sulphate and agglomerated by means of coal tar, the bottom of the apparatus being heated to between 250° and 300° C. The remaining sodium sulphate is utilized in another furnace for the manufacture of the sodium sulphide required in the process, by reduction with carbon in a muffle furnace. The reactions as outlined call only for a consumption of bauxite and carbon, but it is admitted that in practice there are losses by slow volatilization of sodium fluoride and the carrying down of intermediate bodies with the precipitates. The losses of sodium and sulphur are made up by the introduction of a sufficient amount of pure sodium sulphate into the reduction furnace, and the fluorine is replenished by the introduction of hydrofluoric acid from an outside source. As advantages of the process are claimed, the doing away with the costly manufacture of pure alumina and the economy of electrical energy resulting from the electrolysis of aluminium sulphide, while avoiding the considerable difficulties in the preparation and preservation of the compound. The electrolyte is claimed to be easily handled and to satisfy all the conditions of density, fusibility and conductivity required for the manufacture of aluminium. Apart from the complications introduced by the various steps outlined above, not one of which is likely to take place as smoothly as represented by the formula, it is not clear how the actual electrolysis is to be carried out continuously, inasmuch as the sodium fluoride is constantly accumulating in the electrolyte. It is stated that it forms the residue of the electrolytic action and, as mentioned above, is used for the generation of hydrofluoric acid, and it would seem from that as though the process was to be run intermittently. This would, of course, be a great drawback in practical operation, and introduce serious practical complications.

Process of Smelting and Reducing Metals.—C. Diesler, Coblenz, Germany. Patent 764,044, July 5, 1904. Application filed January 12, 1901.

The process is based upon heating or smelting the materials

under treatment in a tightly closed vessel, the heat being supplied by an electric current. The furnace described consists of a cylindrical iron casing, open at both ends. At its bottom end there is introduced a tightly fitting cylindrical casting with an arched top, which latter forms the bottom of the heating chamber. At the top the vessel is closed by an arched cover. A tube of vitrified clay or other non-conducting material is arranged within the outer casing. The electrodes are introduced, insulated through the top and the bottom of the apparatus and are connected together by a carbon resistance for starting purposes. As an illustration of the application of the process to the production of calcium carbide, the inventor states that eighteen hundred kilograms of carbonate of lime, and seven hundred kilograms of charcoal, heated in an apparatus as above, from which the air has been withdrawn, will produce 1000 kilograms of calcium carbide and 1500 kilograms of carbonic gas. The metallic oxides and carbonates used in the process should not be employed in a finely divided form, but as coarse fragments, while coal and mineral silicates should be in finely divided form. The reaction is said to be facilitated when the materials to be treated are compactly pressed into the furnace. A manometer and draw-off cock for the gases are provided, the gases being utilized up to pressure of eighteen to twenty atmospheres within the furnace to facilitate the reduction of the materials treated, while the excess is led off. The principle of the process is stated as being based on the well-known fact that carbonates of metals are smelted in an airtight furnace at a much lower temperature than in an open furnace, and while the oxides require a higher temperature than the carbonates, they are also smelted at a lower temperature in a closed vessel than in an open one, and on the further fact that the pressure produced by the gases evolved by the heat facilitates the combination and reduction of the materials under treatment.

Process of Manufacturing Vanadium and Its Alloys.—Gustave Gin, Paris, France. Patent 765,001, July 12, 1904. Application filed May 9, 1903.

The process consists essentially in the electrolysis of fluoride of vanadium dissolved in molten fluoride of calcium. The fluoride of vanadium is produced during electrolysis by the action of the fluorine upon the anode, which is composed of an intimate mixture of trioxide of vanadium and carbon. The anodes are prepared by mixing vanadium trioxide, obtained by the calcination of vanadic acid in presence of carbon, with finely powdered retort coke or petroleum coke and then adding a sufficient quantity of hot tar, so as to obtain a homogeneous and plastic paste by passing it through a kneading mill. The paste then passes through a mill, where it is crushed by very heavy steel rollers, after which it is pounded under stamps and then forced by hydraulic pressure through a draw-plate apparatus similar to those used for the manufacture of carbon electrodes. The prismatic or cylindrical blocks thus obtained are baked out of contact with the air, in a high-temperature furnace, and the electrodes thus obtained protected from contact with the air until they are required for use. The furnace used for the electrolytic operation is shown in the accompanying Fig. 2. The crucible Q of material unattackable by the electrolyte is filled with a bath C of calcium fluoride. The cathode A is water-cooled and a molten bath B of the metal with which the vanadium is to be alloyed rests upon it. The anode E is supported by a superstructure. When the apparatus is ready to work, the fluoride of vanadium or the fluoride of the metal with which the vanadium is to be alloyed is introduced into the calcium fluoride bath and the vanadium fluoride constantly reforms at the anode during electrolysis. The vanadium alloys with the cathode metal. For alloys with more than 25 per cent of vanadium the cathode section should be appreciably less than the active anode surface, good results and a sufficiently liquid bath being obtained with a medium current density of two amperes per square centimeter of active

anode surface and six amperes per square centimeter cathode surface, and a pressure of between eleven and twelve volts. The metal fluoride introduced at the beginning, f. i., ferric fluoride when iron-vanadium alloys are desired, only serves to start the operation, but it is desirable to add a certain proportion of it during electrolysis to compensate for the loss of a certain quantity of fluorine as gaseous carbon tetrafluoride. The iron, constituting the cathode in this case, is introduced in a metallic state and in small quantities at a
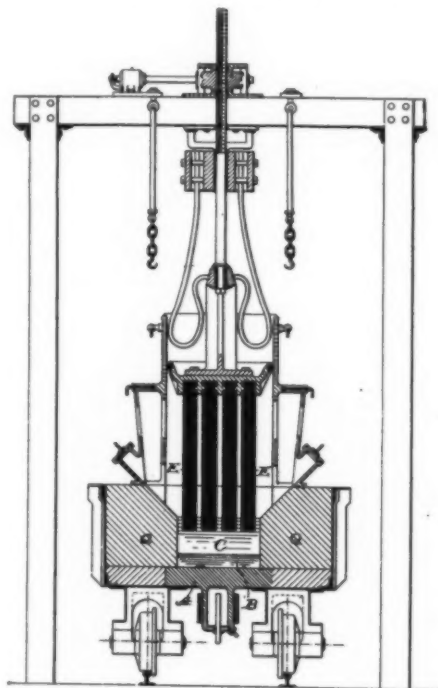

FIG. 2.—PRODUCTION OF FERRO-VANADIUM.

time after each tapping of ferro-vanadium. If no iron be introduced, almost pure vanadium may be obtained, but it is very difficult to tap the latter in a liquid state, and it has therefore to be removed from the furnace as a solid.

System for the Control of Electric Furnaces.—Woolsey McA. Johnson, Laharpe, Kansas. Patent 764,592, July 12, 1904. Application filed November 16, 1903.

The control of the furnace temperature in this system is obtained by connecting the wires of an electrical pyrometer, f. i., of the Le Chatelier types, with a galvanometer, the indicating needle of which is preferably of platinum and insulated from the movable coil. The platinum needle is provided with a metallic contact dipping into mercury, the latter and the contact forming one terminal of a second circuit, the other terminal of which is connected to a movable block, which can be adjusted to any desired point on the scale of the galvanometer. This second circuit includes a storage battery and a solenoid with a soft iron core, which core carries a contact adapted to close a third circuit through the field of the exciter of the furnace dynamo when the second current is broken. When the second circuit is closed by the platinum pointer of the galvanometer touching the adjustable contact mentioned above, which has been set at the required temperature, the solenoid acts and throws a variable resistance and a magnetic cut-out into the circuit, which elements are so adjusted that the cut-out will break the circuit only in case the resistance proves insufficient to quickly reduce the furnace temperature.

STORAGE BATTERIES.

Secondary Battery.—James P. Clare, Quincy, Mass. Patent 762,882, June 21, 1904. Application filed October 31, 1902.

The inventor proposes to use an absorbent cellular substance, which is to be saturated with sulphuric acid and serve as retainer for the latter. As such, he uses the husk or outer covering of the cocoanut, which resists the destructive action of the sulphuric acid. It is prepared for use by being reduced to a granular form, preferably by grinding, washed in fresh cold water and dried. It is then soaked in sulphuric acid of the desired strength for battery work for at least 5 or 6 hours, and is then applied to the battery electrodes and the active material with a mild pressure, only sufficient to pack it against the exposed surfaces of the latter and keep them moist by capillary attraction.

Storage Battery.—H. C. Porter, Waukegan, Ill. Patent 763,-321, June 21, 1904. Application filed November 25, 1901.

The inventor describes a battery, the positive plates of which have a grid with ribs having a W-shaped groove in cross-section. The lower part of the grid rests in a shoe or trough, preferably of hard rubber. The grid is packed full of active material in the usual manner, and is then enclosed in a sheath or envelope, preferably made of lead or a non-oxidizable lead alloy. The whole is then placed under a press, by means of which perforations are punched through the sides of the envelope in such a manner that the metal of the envelope which is displaced by these perforations is forced into the active material. The plate is then formed in the usual manner. The negative plates are without envelopes. A separator composed of a perforated sheet of insulating material, provided on both sides with ribs, serves to keep the positive and negative plates apart.

Battery Plate.—H. C. Porter, Waukegan, Ill. Patent 763,322, June 21, 1904. Application filed July 14, 1902.

The plate is cast in the form of a casing, with a terminal and a series of longitudinal ribs, dividing it into a certain number of pockets. The casing is cast so that it is open on one side. The pockets are filled with active material and the open side is then closed by the use of an oxyhydrogen burner and a small stick of lead. The sides are then perforated in an analogous manner to that outlined in the preceding patent.

Secondary Battery.—J. W. Madigin, Toronto, Canada. Patent 763,565, June 28, 1904. Application filed January 10, 1903.

The plates of this battery are formed out of sheet lead, being first perforated and then corrugated horizontally. They are then placed in a mold and a stiffening rim is cast or burned around them, after which the active material is parted through the perforations, so as to be flush with the rim on both sides of the plate. A plate of fibrous cellulose or wood fiber, which has been chemically treated with an ammoniacal salt, is placed between the plates. As the separator plates are porous, it is claimed that they draw the electrolyte by capillary attraction from the bottom of the cell up to the top of the electrodes.

Method of Separating Mechanically Entrained Globules from Gases.—Thomas A. Edison, Llewellyn Park, N. J., assignor to Edison Storage Battery Co. Patent 764,183, July 5, 1904. Application filed November 28, 1902.

The invention is intended to do away with the undesirable effects caused by the gases developed from storage batteries, especially at the end of the charging period. These gases are charged with finely divided globules of the electrolyte, which have been carried off mechanically. The method described consists in discharging the escaping gases at such a velocity and in such a manner, that they will be directed against a film of solution with sufficient force to overcome the surface tension of the latter; the entrained globules then coalesce with the film and permit the gases to escape in a substantially dry condition. The arrangement is illustrated in Fig. 3. The top of the bat-

tery receptacle 1 is provided with a neck 2, with a tight joint. This neck has a flat seat 3, upon which rests a mushroom valve 4, having a weighted stem 5. A casing 6, with vents 7, is screwed into the neck 2, and a small deflector plate 8 is arranged above these vents. A disc of wire gauze 9 covers the mouth of casing 6. A neck 10, with hinged cover 11, rubber packing 12, spring 13 for opening, and yoke 14 for closing the cover, is also provided. The check valve 4 is normally closed by its weight, until the pressure of the gases which have been accumulating in the top of the vessel is sufficiently high to force the valve open. The gases then rush at a high velocity against the base of the neck 2 and casing 6, and form a liquid film, which coats the base of the casing 6 and also deposits on the seat 3. As soon as the gas pressure has been relieved, the valve closes again and sticks to a certain extent to its seat, on account of the liquid film, in a manner analogous to the sticking of two glass plates together, if a film of liquid is interposed between them. If the valve is now raised again by the pressure of the gases, the latter impinge against the liquid film with sufficient force to overcome its surface tension and to cause the entrained globules of liquid to coalesce with the film and thus
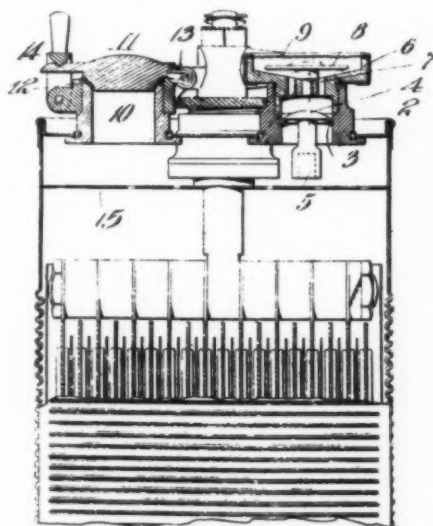

FIG. 3.—EDISON STORAGE BATTERY.

be separated from the gases. If for any reason the gas pressure should become so great in the cell, that a complete separation is not effected in the way just described, a further separation will be effected by their striking the dash plate 8. It is stated though, that the purpose of the dash plate is not particularly to supplement the operation of the check valve 4, but to cause the gases to be diluted and deflected, so as to pass through gauze 9 in a non-combustible condition. It has been found that, if the deflector is not used, the gases frequently pass through the vents 7 in a sufficiently concentrated form as to burn above the gauze, and when the gauze becomes too hot, an explosion takes place beneath it, which communicates with the gases in the cell and does serious damage. The neck 10 serves for replenishing the cell. A diaphragm 15 is preferably arranged, made of hard rubber and perforated. If such a diaphragm is employed and overcharging of the cell causes the electrolyte to froth until the diaphragm is reached, the latter is coated with a film which closes the perforations and effectually assists the operation of the check valve separator, as it acts in substantially the same manner as the latter. The surplus liquid, not retained by capillarity in the bore of the casing 6, will, of course, flow back again into the cell over the valve seat, when the valve opens again, so that it is only necessary to replenish the electrolyte from time to time with distilled water.

Battery Cell.—W. O. Duntley, Chicago, Ill. Patent 764,282, July 5, 1904. Application filed Feb. 15, 1904.

The invention is intended to facilitate the removal of sediment from the active material of the battery grids, which has fallen down to the bottom of the cell. The inventor supports the battery grids on staggered supports on the bottom of the cell and provides an opening, which is preferably circular, in the cell bottom. Various constructions are described, intended for a quick and efficient closure of the opening.

Storage Battery.—T. Kitsee, Philadelphia. Patent 765,082, July 12, 1904. Application filed August 9, 1902.

The battery comprises a containing jar, which contains a frame of hard rubber, slotted at the top and bottom, and having an internal flange extending all around the frame. A pair of supporting plates of porous material fit snugly against these flanges, thus closing the sides of the frame. The outer faces of the plates are provided with a series of projecting pins, arranged in a staggered fashion and acting as supports for a thin strip of lead, wound in zig-zag fashion on them, so that the outer edges of the strip are flush with the free ends of the pins. The ends of each strip project through openings in the top of the frame, and form the battery terminals. A body of active material is packed around the pins and conductors. Covering plates are provided to hold the active material in place, the inner sides of which, however, do not come into contact with the pins, the space remaining between the two being also filled with active material. One of the supporting strips and its pins will form the positive, and the other the negative electrode.

Storage Battery.—T. A. Willard, Cleveland, Ohio. Patent 765,060, July 12, 1904. Application filed August 13, 1903.

The object of the invention is to provide a non-conducting sheath or envelop for the electrodes. The sheath is preferably made of hard rubber, in the shape of a box open at the top. The side walls have a series of vertical ribs and are provided with numerous perforations for the circulation of the electrolyte. The peculiar shape of these perforations constitutes a principal feature of the invention. They are cone-shaped, the larger openings being on the inside of the sheath. To effect this, it is stated, the surface of the sheath is blown full of cone-like projections, the points of which are subsequently ground off. It is claimed that in this manner the sheath is not deprived of any elasticity or structural strength as in the ordinary practice of making perforations, and that the peculiar cone-shape of the openings renders them good supports for the active material.

GALVANIC ELEMENTS.

Electric Battery.—P. J. Kamperdyk, New York. Patent 763,674, June 28, 1904. Application filed October 14, 1903.

The object of the invention is to provide a carbon electrode of great superficial area. For this purpose a number of carbon balls are strung like beads on copper wires coated with an incorrodible metal as platinum, the wires being joined at the upper and lower ends to copper plates, which are protected against corrosion by a layer of lead or a coating of cement. They are enclosed in porous cups, supplied with depolarizing liquid. The negative electrodes consist of two flat zinc plates, immersed in the battery electrolyte and held close to the walls of the cups by distance pieces. Several alternative carbon electrode constructions are shown, embodying the same principle as the above.

Method of Converting the Energy of Fuel into Electrical Energy.—Hugo Jone, Chicago. Patent 764,595, July 12, 1904. Application filed November 7, 1901.

The object of the invention is to obtain electric energy from fuel by means of a galvanic cell. The latter consists of a rectangular vessel, the material of which is not affected by caustic potash. An iron plate with a ledge running around its edge, thus forming a sort of flat pan, rests upon the bottom and forms the receptacle for the positive electrode of tin, either solid or melted. A square vessel of porous carbon, as wide as, but considerably smaller than, the rectangular vessel, rests upon the latter by means of a flange and is insulated from it. This vessel serves as the negative electrode and contains a mass of mercuric oxide which acts as depolarizer. The flat pan mentioned above is only a little longer than the porous-carbon vessel, and the space in the containing vessel, not occupied by the two, is partitioned off by a porous plate, which may be made of sulphide of calcium, and a sliding door. In the space thus partitioned off is placed another porous vessel. The battery electrolyte is caustic potash, and the temperature at which the battery is operated may be considerably below 300° C., and as low as 150° C., in which latter case the tin electrode is no longer fluid. In the operation of the cell the mercuric oxide is stated to be reduced to mercurous oxide, while the tin is converted into stannous oxide, which is gradually dissolved in the electrolyte to stannite of potassium. The latter diffuses through the partition mentioned above into the other part of the vessel, the sliding door being open. In the second porous vessel the stannite of tin is precipitated by a hot concentrated solution of barium hydroxide, the sliding door being closed at the time when the addition of the barium salt is made, so as to prevent the barium stannite from passing into the other compartment and covering the surface of the metallic tin. The barium stannite is allowed to accumulate in the porous vessel and removed from time to time. It is reduced to metallic tin in a reverberatory furnace by means of coal or some other suitable fuel, the waste gases from the coal being utilized for furnishing heat to the battery cells. The barium oxide thus obtained is dissolved in hot water and is available for use again, while the metallic tin is also returned to the cell. The mercurous oxide obtained by the operation of the cell is allowed to accumulate until nearly all the mercuric oxide is converted into it. It is then removed and a new quantity of mercuric oxide put into its place. The mercurous oxide is treated in a retort with concentrated nitric acid, so as to convert it into mercuric nitrate. Steam is then admitted into the retort and the mercuric nitrate decomposed according to the equation $Hg(NO_3)_2 = HgO + 2NO_2 + O$. The nitrogen peroxide thus evolved is carried into a condenser coil and air is admitted to it, thus converting it into nitric acid, which may be used over again. The waste gases from the heating of the retort are also utilized to furnish heat for the cells. It is stated that stannic oxide or stannite of potassium is not formed in the electrolytic oxidation of the tin, or at least to a very limited extent, if the oxygen of the air is excluded and the cells are kept at a constant elevated temperature. If the cells were allowed to cool, the potassium stannite would be liable to form stannate, which would require a much higher temperature for reduction than the stannous compound. It is claimed that the removal of the battery product, the stannous oxide, prevents the action of the battery from being stopped by saturation of the electrolyte with stannous oxide, coupled with accumulation of stannous oxide on the surface of the metallic tin. The electromotive force of the cell is given at 1.03 volts and the current strength of a cell of the capacity of one gallon of liquid as twelve amperes, when the external resistance is 0.04 ohm.

Galvanic Battery.—C. B. Shoenmehl, Waterbury, Conn. Patent 764,826, July 12, 1904. Application filed November 2, 1900. Patent 764,827, July 12, 1904. Application filed July 23, 1901.

The battery of the first patent is of the zinc-copper oxide type, the zinc element having a ring-shape. The copper oxide is contained in a conical, perforated basket, larger at the top than at the bottom, means being provided for lifting the basket out easily and cleaning it. In the second patent the form of the zinc electrode is the same, but the form of the conical basket has been changed. A perforated cone is now placed on the bottom of the basket, with its largest side down. Thus,

both sides of the receptacle for the copper oxide are now tapering, with the result that the material can quickly free itself when the receptacle is open and inverted. Besides, both exterior and interior surfaces are exposed to the action of the electrolyte

Electric Battery.—P. J. Kamperdyk, New York. Patent 764,813, July 12, 1904. Application filed December 26, 1902.

The invention relates especially to the zinc pole of primary batteries, which is shown in the form of a plate. The latter is produced by placing a frame consisting of a series of copper wires covered by electrolysis or otherwise with a coat or plating of a non-corrodible conducting material as platinum into a mold, which is then filled with melted zinc. The latter en-
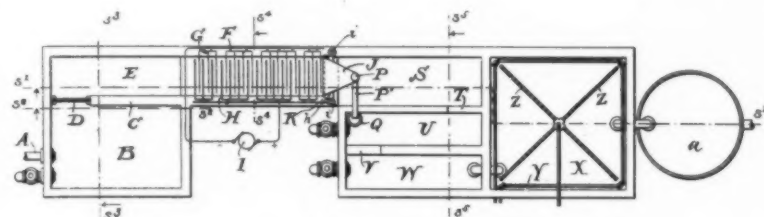

FIG. 4.—APPARATUS FOR TREATING SEWAGE.

tirely encloses the wires, which thus serve as support for the zinc plate and permit it to be used much longer than ordinary plates.

MISCELLANEOUS.

Apparatus for Treating Sewage.—W. J. Schweitzer, White Plains, N. Y. Patent 763,026, June 21, 1904. Application filed July 31, 1903.

A plan-view of the proposed apparatus is given in Fig. 4. It comprises a receiving tank B, which is fed by pipe A. The receiving tank contains a baffle wall C, which breaks the force of the flow and directs the material through the screen D, which breaks up the semisolid matter contained in the sewage. The flow then passes into the settling tank E, where sand, silt, etc., are deposited. From there it enters the electrolyzer F, where are arranged a series of negative electrodes G and positive electrodes H. They are preferably in the shape of a comb, having teeth which are trapezoidal in cross-section, the shorter side of the trapezoid teeth being arranged facing the direction in which the liquid is flowing. Each alternate plate has its teeth in staggered relation to the next contiguous plate in the series. The electrodes, if of cast iron, should be galvanized. The sewage is stated to be generally sufficiently saline to contain enough sodium chloride so as to disinfect the liquid thoroughly by the chlorine liberated by electrolysis. Common salt may, however, be added in the chamber B. The best results are said to be obtained with a current of five volts and three amperes per gallon of solution, no further data as to current density being given. Fatty matters rise to the top in the electrolyzer, and are removed by skimmer J into pipe P, which connects with a trough P′ leading into tank Q. The liquid flows very slowly from the electrolyzer over wire R into tank S, over wire T into tank U, and over wire V into tank W, for the purpose of settling and precipitation. From there it goes to the settling chamber X, where it is treated with a weak solution of lime injected by pipes L, perforated in supply pipes Y, being placed along the outer walls of the chamber. From the settling chamber X the liquid goes to a sand filter a, and is then discharged into a stream or in any suitable manner.

Process of Electrically Extracting Essential Oil.—G. D. Burton, Boston. Patent 763,151, June 21, 1904. Application filed June 27, 1898.

Apparatus for Making Extracts by Electricity.—Same inventor. Patent 763,152, June 21, 1904. Application filed same date as above.

The object is to facilitate and hasten the operation of extracting essential oils from bark or other vegetable matter. The apparatus comprises an extraction tank provided with a conical hood, from the top of which a pipe leads to a condenser, which, in its turn, is connected with a receptacle. The electrodes in patent 763,151 consist of a pair of transverse plates, at opposite sides of the extraction tank. A perforated guard plate prevents the material under treatment from coming into contact with the electrodes. In carrying out the process, the material from which the essential oil is to be extracted, *f. i.*, tanbark, is placed in bags and brought into the tank. The latter is filled with water or any suitable aqueous solution, and a current is passed varying according to the size of the tank and ranging from 400 to 500 volts, and from 100 to 150 amperes; the current density is not given. The tank may be provided with a coil of perforated pipes for supplying air or steam under pressure for agitating the loose material in the tank. The apparatus shown in patent 763,152 is substantially the same, but the electrodes are arranged quite differently. Instead of being constituted of two transverse sheets as above, they are composed of transverse conductors, preferably in the form of rods or tubes. They are arranged on opposite sides of the tank and are connected with each other by longitudinal, perforated tubular conductors. Consequently, only the heating effect of the current is utilized in this apparatus and a current of comparatively low voltage and high amperage is employed from $2\frac{1}{2}$ to 10 volts, and from 1000 to 1500 amperes. The material, *f. i.*, tanbark, is again placed in the apparatus inclosed in porous bags, into a liquid consisting of water and sodium chloride or other suitable solvent, of a specific gravity of 1.03 to 1.05. The vapors from the heated liquid are condensed in the condenser and thence pass to the receptacle.

Magnetic Ore Separator.—F. J. King, Croydon, England. Patent 765,013, July 12, 1904. Application filed March 31, 1902.

The distinguishing feature of this invention is the preliminary treatment of magnetic ore, by passing it over an inclined table, below which are arranged a series of transverse magnetic bars, connected alternately to the opposite sides of a series of very powerful electromagnets. In this way very strong and uniform magnetic fields are set up between the bars, and the ore passing over them becomes stratified, as it were, as the magnetic particles turn on their axes as they change from field to field, and thus gradually work their way to the top of the ore. After this treatment the ore is subjected to the influence of the separating magnets, which attract the magnetic particles, which now form the top layer of the ore. A belt passes over the magnet poles and carries the magnetic portion off, while the tailings drop right down at the end of the inclined table. The inclination of the table is adjustable in order to suit different materials.
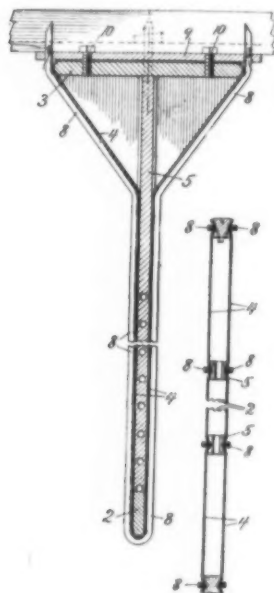
Electrochemical Gas Lighter.—Ignatz Rothstein, Berlin, Germany. Patent 760,567, May 24, 1904. Application filed May 12, 1903.

The gas lighter is provided with a small battery, the poles of which are connected by a short platinum wire. A number of thin platinum wires in the form of a cone extend from this short wire, the apex of the cone being situated at the wire and the outer ends being supported by an arm, extending from a shell which is situated on the battery conductors. The short wire becomes hot when the circuit is closed and renders the thin platinum wire cone incandescent, whereby the gas is ignited.

RECENT METALLURGICAL PATENTS.

WET PROCESSES.

O. P. Ankeny (patent 764,973, July 12), describes details of construction of filter presses for separating slimes from the liquid, in connection with the cyanide process. The apparatus contains, as usual, a number of filtering cells, consisting of a peripheral frame about which a canvas is stretched. A vertical cross-section of such a cell is shown in Fig. 1, and a horizontal cross-section in Fig. 2. In forming such a cell, the canvas 4 is folded at the middle point of its length about the lower bar 2 of the frame and brought up on opposite sides, the upper ends of the side bars having flaring portions. The ends of the canvas 4 are folded over the edges of the top bar 3, and clamped thereto by the clamping plate 9, which is secured to the top bar 3 by bolts 10. Spacing bars 5 are provided which extend across the cell from top to bottom at intervals of a few inches. These bars have the same width as the bottom bar 2. The edges of these spacing bars are grooved and U-shaped clamps 8 press the filtering web into the grooves of the spacing bars.

G. Moore (764,486, July 5) patents "the process of filtering slimes and the like, consisting in immersing a filter

FIGS. 1 AND 2.—FILTER PRESS CONSTRUCTION.

in a bath containing the slimes and a fluid in which they are suspended, forcing said fluid through said filter by difference of pressure between opposite sides thereof, whereby the slimes are deposited thereon in a layer of the requisite character; removing the filter from said bath and cleaning it by air-pressure applied to the back thereof."

J. Smith (764,870, July 12), patents a horizontally-set rotary apparatus for the treatment of ores by the cyanide process. Such ores are frequently too heavy to be worked by ordinary extraction in upright apparatus, since the great specific gravity of the materials continually causes them to sink to the bottom and clog the machinery. A cross-section of the revolvable drum is shown in Fig. 3, showing the shelves, riffles or agitators 12, distributed around the internal periphery of the drum. The supply of oxygen (necessary for the solution of the precious metals in the cyanide solution) is provided for by the air-trap 14. It is a chamber with an opening 15 to the atmosphere. From this chamber leads a coil of pipe 16 which runs around the periphery of the drum and terminates with an open end at 17.

FURNACE PROCESSES.

R. Baggaley (764,332, July 5) patents a Bessemer converter for treating copper matte which can be cooled with air, while the extent of the cooling and the place of its application may be regulated as desired. For this purpose a series of ventilating air passages open to the atmosphere above and below is provided, the inlet being lower than the outlet.

C. W. Speirs (765,299, July 19), patents mechanical details of crucible furnaces which can be tilted for discharging the molten contents of the crucible without removing the same

from the furnace. The object of the details of construction described by the inventor are to improve the means for supporting the crucibles in the furnace, to improve the combustion in the furnace, to retain the external parts of the furnace relatively cool, and to prevent as far as possible the escape of the products of combustion into the building in which the furnace is situated.

R. Robinson (765,323, July 19) patents details of construction of a refining furnace. Three flues are provided at each end of the furnace, the two outer ones being for the introduction of the flame to the melting chamber, while the center ones
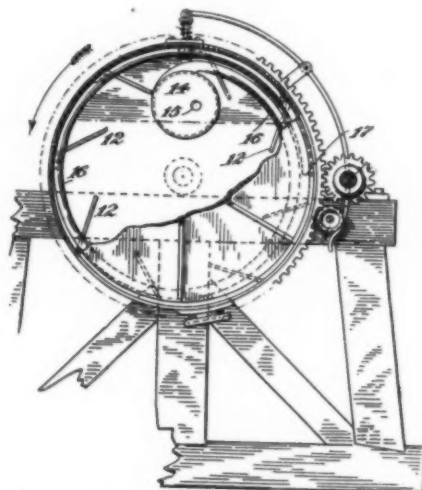
FIG. 3.—ROTARY APPARATUS FOR LEACHING ORES.

are openings leading to the draft-stacks for carrying off waste heat and spent gases. There are provided two upright standpipes on each side of the furnace having nozzle-shaped extension pipes which point toward the center of the melting chamber. Arranged on each of these nozzle-shaped pipes are adjustable twyers that, when in use, are lowered into the molten mass of the metal, and a forced draught of the air and gas, or of steam and gas and air is introduced into the molten gas to burn out the impurities.

C. W. Bray (763,847, June 28) patents a heating furnace for the reheating of plates and sheets, such as the packs formed in the reduction of black plates and sheets for tinning. The object of the details of his construction is to apply the heat evenly and uniformly to the metal while resting upon an endless carrier of annular form. An automatic intermittent movement is imparted to the carrier which moves step by step, allowing the insertion of a series of sheets during each interval of rest.

J. Hirschmann (763,892, June 28) patents a furnace for heating slabs or bars, such as tin-plate bars. The object of his construction is to carry the bars through the furnace and eject them, without causing marks on the plates which have occurred where water-cooled pipes are used for supporting the plates or moving them through the furnace.

Current Notes.

Cal.; George G. Hitchcock, Claremont, Cal.; F. L. O. Wadsworth, Morgantown, W. Va.; William C. L. Eglin, Philadelphia, Pa.; E. Humblot, San Francisco, Cal.; P. McN. Bennie, Niagara Falls, N. Y.; J. W. Best, Denver, Col. At the August meeting of the Board of Directors the names of the following gentlemen will come up for election: Joseph Clark, Jr., Stanley, Idaho; Benito Herrera, Los Angeles, Cal.

NEW MINING JOURNAL.—The first number has just been issued of the *Mining Magazine*, "an international monthly review of current progress in mining and metallurgy." The publisher is Mr. W. J. Johnston, the former proprietor of *Electrical World*, and later of the *Engineering and Mining Journal*. The editors are Dr. H. Foster Bain, Mr. Henry S. Fleming, Mr. Edwin C. Johnston and Mr. William Young Westervelt. The general policy of the paper is to provide the mining industries with a monthly journal corresponding in scope and character to the *Engineering Magazine* in general engineering. The first issue of the *Mining Magazine* is very creditable and contains articles by John A. Church, F. L. Ransome, C. Henrich, H. S. Fleming and W. R. Ingalls, the latter giving interesting notes on the metallurgy of copper, lead and zinc. A special feature is a very useful "Mining Digest," being a condensation of important articles from the leading technical periodicals; it has evidently been prepared with great care. ELECTROCHEMICAL INDUSTRY wishes every success to the new enterprise.

Correspondence.

ELECTROMETALLURGY OF IRON AND STEEL.

To THE EDITOR OF ELECTROCHEMICAL INDUSTRY:

With respect to your article on the electrometallurgy of iron and steel, published on pages 280 and 281 of your July issue, permit me to call your attention to an error in the statement of the selling price of the La Praz electric steel given in the abstract of my preliminary report to the Honorable the Minister of the Interior. The sentence in question should read: "The selling price of the steel varies from $363.60 to $123.60 per ton, depending upon quality."

If given in francs the figures per ton of 2000 pounds are 1,818 francs and 618 francs, respectively.

EUGENE HAANEL,

Ottawa, Canada.   Superintendent of Mines.

Book Reviews.

READY REFERENCE TABLES.—Vol I.: Conversion Factors of every unit or measure in use. By CARL HERING. New York: John Wiley & Sons. 196 pages. Bound in flexible morocco. Price $2.50.

This is a "dear" little book. Considering simply its size and weight, the first impression will probably be that it is very expensive. A more intimate acquaintance with the book and its steady use for several weeks should, however, convince the owner that, like all good and expensive things, it is many times worth its price.

The features which make this reference book especially valuable are completeness, thoroughness, accuracy and consistency. It does not appeal to a single class of engineers, but to all of them. While adapted specially to the use of American and British engineers and physicists, etc., it also gives foreign units and measures, and is not restricted to those in use at present, but also gives obsolete units. This will surely be appreciated by all who have to refer occasionally to foreign or old literature. It may be that, for the sake of completeness, the author has gone a little too far and has given unusual and obsolete units which may never be looked up by anybody.

Yet this completeness of the tables will be thoroughly appreciated whenever one comes in practice across an unusual unit for the meaning and value of which one would look in vain in other books.

The aim at completeness accounts partly for the great length of some of the tables. There are, however, two other factors which cause the great intricacy and complexity of our system of units and measurements. One is expressed by Lord Kelvin in the following words which the author has placed at the head of his preface: "I look upon our English system as a wickedly brain-destroying piece of bondage under which we suffer. I say this seriously. I do not think any one knows how seriously I speak of it." This source of complexity of our systems of units would, of course, be removed by the general and consequent introduction of the metric system and c. g. s. system.

Yet, there is another factor which causes complexity and which will render conversion-tables always necessary. We will always have gravitational units, heat units, electrical units, light units. The energy of a waterfall is most conveniently given in kilogram-meters, the power of a dynamo in kilowatts, etc.; and for the conversion from one system to another we will always need conversion factors. By the way, the relations which exist between the groups of gravitational, heat, light, and electrical units are represented on page 3 in a simple diagram, which is evidently a home-made affair, but is very instructive.

The thoroughness with which the book has been prepared is emphasized by the fact that, as the author says in the preface, the conversion factors are not compiled but have all been especially recalculated from the exact legal values as far as such values exist, and from the very best, most standard, and most authoritative values attainable, when no legal values existed, and that the greatest possible care was taken in selecting these fundamental values. The authority for each fundamental value is given in the book, and since all conversion factors were calculated from the same set of fundamental values, they are all consistent with each other, forming a single, inconvertible uniform system.

Concerning the accuracy to be expected, the author states that the calculations were very carefully made, in many cases by two entirely different methods, and the resulting values were checked and cross-checked, often several times. For most of the values a final comparison was made between the electrotyped plates and the original calculation sheets. A special feature is that a great many of the conversion factors were checked by authorities, especially members of the staff of the National Bureau of Standards, etc. All these figures are marked with an asterisk, and all these values were checked again by the original authorities after the pages were electrotyped.

The author has adopted the general system to give six places of figures and seven of logarithms. Here it may again appear that he has gone too far, since in many cases the accuracy of some of the fundamental figures is not sufficient to warrant giving six places of derived figures. The author, however, heads off this criticism by saying that he has maintained the system uniform throughout the tables in order to enable changes to be made by mere proportion, when more accurate fundamental values become attainable in the future. An admirable feature has been added in the form of convenient approximate values consisting often of only one, and generally of only two digits. These digits are so chosen that they reduce the calculation to the simplest possible; they will suffice for most of the ordinary computations, being always correct within 2 per cent.

It is impossible to give in a review, which must be necessarily short, an idea of the full scope of the tables. We will briefly give the contents. The introduction (twenty-six pages) deals with the inter-relation of units; compound names of units; distinction between units and quantities measured in

those units and the reduction of formulas from one kind of units to another (these pages are worth reading, although they deal with very elementary subjects) ; ratios, percentage, condensed numbers, accuracy of approximate or abbreviated numbers, accuracy of logarithms, absolute system of units, dimensional formulas, decisions of international congresses The introduction is concluded by a full table of the various physical quantities and relations, giving name, symbol, derivation, dimensional formula and c. g. s. and practical units. This table is based on that of the committee of notation of the Chicago International Electrical Congress, but is far more complete.

Then follow the tables of conversion factors. Twelve pages deal with lengths, 4 with surfaces, 11 with volume, 6 with weights or masses, 8 with weights per length, weights per surface (pressures), weights per volume (densities), followed by tables of weights of water and volumes of water. Seven pages deal with energy, work, heat, 4 with power, followed by tables of forces, moments of inertia, linear velocities, angular velocities, frequencies, linear and angular accelerations, angles, solid angles, grades, time, flow of water.

Forty-eight pages deal with electric and magnetic units (among them brief chapters on electrochemical equivalents and electrochemical energy, and tables of electrolytic deposits in mass per time). Then follow 5 pages of light units and a full table (14 pages) of thermometer scales, giving the relations between degrees Centigrade, degrees Fahrenheit, degrees Reaumur and degrees of absolute temperature, and a concrete scale which is a novel and very useful feature. It gives numerous temperatures at which various materials boil or melt, thus enabling one to so maintain or measure these temperatures. Exactly this method has recently been made use of in the thermometric department of the National Bureau of Standards. Most of these figures are only approximate, although they have been compiled from the best authorities. There are, however, some rather large discrepancies ; the worst is in the case of the melting point of manganese, which is given twice, once as 1900° C., and the other time as 1245° C., the latter is stated to be the melting point of manganese 99 per cent pure, as determined by Heraeus (probably manganese free from carbon, obtained by reduction with aluminium). These inconsistencies, of course, are not the fault of the author ; they emphasize the importance of redeterminations of melting points and boiling points with the use of pure materials. The book is concluded by some tables of money, money per length and money per weight, scales of maps and various useful numbers, and a very complete index of twenty-two pages.

The book is thoroughly up-to-date, in some cases (for instance, "abvolts," "abstatvolts" among the electrical units), even ahead of the times. In the conversion tables all the various measures used in practice, more especially by engineers and physicists, are given with their values in terms of as many of the others as they are likely to be converted into in practice ; the reciprocals of these are also given, thus enabling every calculation involving the conversion of one measure into another to be reduced to a single simple multiplication. each table is preceded by a short introduction ; the explanations given there are brief and to the point and well worth reading. The somewhat mysterious remark on pages 128 on the Gibbs-Helmholtz equation would have been clearer if this equation had been given and explained this could be done in two lines.

The reviewer has used the book constantly for about seven weeks, in the average about twenty times a day. Only in two cases he did not find directly what he was looking for. The first case was when he wanted to convert the figure of specific electric resistance given by an American manufacturing company in ohms per cubic inch into ohms per cubic centimeter. Ohms per cubic inch are not given in the table (page 103) for specific resistance. Of course, the conversion is the same as from inch to centimeter (page 30). The other case was when

the reviewer wanted to find the value of one heller (an Austrian coin). The book states on page 164, under Austria-Hungary : 1 krone = 0.203 U. S. gold dollar. "The small unit is the heller." There is no conceivable reason why it should not state directly that 1 krone = 100 heller. But this is the only vague statement which the reviewer has found in the book. The arrangement of the various subjects is very convenient, and with the aid of the extensive index it is easy to find quickly what one is looking for. Print and mechanical make-up are excellent. The book is of such size that it may be carried conviently in the pocket. It appears as volume I. of "Ready Reference Tables." If the following volumes turn out to be as valuable as the first one, the serial will form one of the most handy and indispensable reference works for every engineer and scientist. For the present we ought to be grateful to the author for what he has given us in volume I.

TRANSACTIONS OF THE AMERICAN ELECTROCHEMICAL SOCIETY.—
     Vol. V. Philadelphia : American Electrochemical Society.

This volume covers the proceedings of the fifth general meeting, held at Washington, D. C., from April 7 to 9, of this year. It is an attractive-looking volume of 284 pages and contains as frontispiece an excellent portrait of the new president, Prof. H. S. Carhart. It contains the papers and discussions in full, concise abstracts of which were given in our May issue. A paper by Mr. Voege, which was not read at the meeting, on account of limitations of time, and which is now printed in the Transactions, is abstracted at some length on another page of our present issue. The volume also contains the proceedings of the first meeting of the New York section, a report of which was given in our February issue.

The Committee on Publication should take a little more care in editing the discussions. Surely, not the whole discussion of Mr. Addicks' paper was "communicated before the meeting" as indicated on page 122. Everybody has a right to consider the electronic theory either as ridiculous or as the foundation of new developments, as he pleases ; but the theory should not be made unnecessarily mysterious. The equation given in Dr. Gahl's remark on page 146 is a Chinese puzzle ; this is not Dr. Gahl's fault, but evidently due to the fact that the printer had not the proper type for electronic charges ; hence something else was printed. The first remark of Mr. Hering, on page 118, appears senseless, simply because some remark of somebody else has been left out to which Mr. Hering replied. It is inherent in human nature that in a discussion one sometimes makes a remark which he would not like to see in print. In revising the discussion the remark is suppressed, but the Committee on Publication should see that such suppression of remarks should not destroy the sense of replies made afterwards by other speakers. Other similar examples could be pointed out.

THE ELECTRIC FURNACE. By HENRI MOISSAN. Authorized
     translation by VICTOR LENHER, Ph. D., Easton, Pa. : The
     Chemical Publishing Co. ; 305 pages. Price, $3.00.

It is somewhat surprising that seven years have passed since the publication of "Le Four Électrique" before the appearance of an English translation. The original book marked an important point in the history of chemistry, since Moissan's work undoubtedly gave a new stimulus to the study of inorganic chemistry. Organic chemistry possesses great attraction for chemists, because of the interminable series of new compounds which may be produced ; while in the case of inorganic chemistry it is by no means so easy to obtain something new. Moissan, however, by developing the use of the laboratory electric furnace, put a new tool in the hands of the chemist and opened a fresh field of great interest for investigation and research.

Anyone who has had experience in translation from one language to another realizes the difficulty of avoiding such literalism as has a bad effect on the language of the transla-

tion. This difficulty is unfortunately conspicuous in Dr. Lenher's work. The absence of an index also seems inexcusable in any scientific book published in America.

Besides being a translation of "'Le Four Électrique" as it was published at Paris, in 1897, the present book contains interesting additional material supplied to the translator in manuscript by Professor Moissan. For example, under carbides, compounds of carbon with the following elements are found: Potassium, sodium, neodymium, praseodymium, magnesium, glucinum and iron. Under silicides: Manganese, nickel, cobalt and platinum. Under borides: Calcium, strontium, barium, nickel, cobalt and glucinum. There is also a description of certain phosphides, such as those of the alkaline earths, iron, chromium, nickel, etc.; and of arsenides of the alkaline earths.

In writing his book on the electric furnace Professor Moissan has spared no pains to explain thoroughly the manipulation of his furnaces, the methods of performing his experiments, and the analysis of the resulting products, and for this reason the book should be in the hands of all who are engaged in investigations of the chemistry of high temperatures. Moreover, the work is full of suggestions for further study and of methods which are generally applicable to the working out of new problems.

One of the most interesting portions of the book is the study of the various modifications of carbon which culminated in the production of artificial diamonds. The great interest attaching to the final achievement has perhaps caused less attention to be paid to the preliminary work than it deserves.

In spite of the immense amount of valuable work Professor Moissan has done in this direction, the subject is by no means exhausted, nor can it be said that he has definitely proved all his statements. Berthelot has recently shown (*Comptes Rendus* CXXXVII., page 589) that the film formed on the globe of an incandescent lamp which has been in use for some time contains no graphite. Moissan, on the other hand, describes experiments in which he found that the film on the globe contained graphite, and comes to the conclusion that "when gaseous carbon assumes the solid condition it always gives graphite."

As another example of a doubtful point: Moissan illustrates the vaporization of carbon by heating the outside of a carbon tube containing a boat filled with silicon, with an arc, and describes the formation of silicon carbide from the combination of the vapors of silicon and carbon. Acheson, on the other hand, has shown that by heating silicon carbide to a very high temperature, the silicon is vaporized, leaving the carbon behind as graphite, which has the exact form of the crystals of silicon carbide.

As an example of a direction in which further investigation may proceed, reference may be made to the formation of double carbides, such as glucinum borocarbide, prepared by Lebeau and described. So far little has been done in this direction, though the results would undoubtedly be of considerable scientific interest, and might possibly lead to the development of valuable industrial products.

No one engaged in work with the electric furnace can afford to be without this book.

ANALTICAL CHEMISTRY: VOL. II., QUANTITATIVE ANALYSIS, by F. P. Treadwell. Authorized translation from the second German edition by William T. Hall; 8 vo., pp. 654; price $4.00. New York: John Wiley & Sons, 1904.

Since Professor Treadwell's removal to the Polytechnicum at Zurich, German-speaking students have been reaping the benefit of his instruction, but this translation again brings him into contact with his former American students.

The work is divided into five sections; viz., general directions, gravimetric determination of the metals, gravimetric determination of the metalloids, volumetric analysis, and gas analysis. The ground covered is so broad that a complete treatment of the subject is impossible in one volume; as a necessary result we have therefore a book of great value in giving to the student his first practices in the important determinations of quantitative analysis, but of almost no value to the advanced analytical chemist. We unhesitatingly recommend the book as probably the best in the English language for the use of students, or for a beginner in the subject wishing to learn quantitative analysis by self-instruction.

ST. LOUIS EXPOSITION.

Exhibit of Baker & Co.

The exhibit of Messrs. Baker & Co., Inc., the well-known platinum, gold and silver manufacturers and refiners, of Newark, N. J., is in the Mines and Metallurgy Building, block No. 40, and is under the direct supervision of the United States Government.

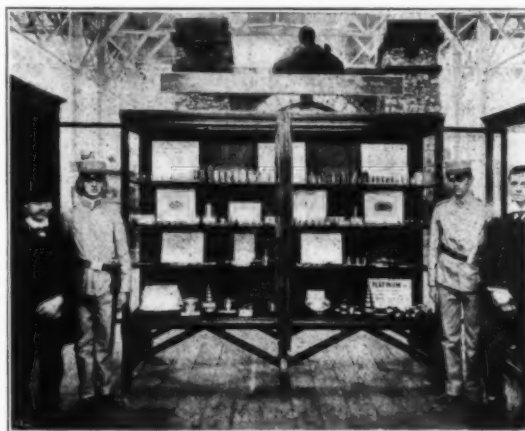The display, an illustration of which is herewith given, will

EXHIBIT OF BAKER & CO.

be found especially interesting to electrochemists, chemists and metallurgists, as it includes platinum and the different metals and salts of the platinum group, a large variety of manufactured platinum ware, platinum rivets, sparking points and platinum in its various forms as applied to the arts and industries.

Chemical Exhibits of the German Government.

Under the auspices of the German Government, the chemical manufacturers and scientists of Germany have prepared a very extensive and highly interesting exhibit, the leading idea being to show the development of chemistry in Germany. Besides thirty-nine chemical manufacturers and twenty-five makers of chemical apparatus, 117 professors and instructors of universities are represented by exhibits. The exhibit is in the electricity building and contains a reading-room, an alchemistic laboratory, Liebig's laboratory, the exhibits of general and inorganic chemistry, pyro-chemistry, balances, electrochemistry, organic chemistry, dyeing laboratory, and physiological chemistry. The exhibition is very well arranged and contains much of special interest to electrochemists and electrometallurgists. We hope to give in our next issue a fully illustrated description of those parts of this exhibition which should especially appeal to our readers.

Exhibit of the Roessler & Hasslacher Co.

The Roessler and Hasslacher Chemical Co's. exhibit is to be found in the Palace of Liberal Arts, Block 66. The products of the company are shown in a most instructive and, at the same time, interesting grouping, their booth representing the painting by D. Teniers, Jr., "The Old Alchemist."

GAS BLOWERS AND EXHAUSTERS.

The adjoining diagrams show modern types of gas exhausters made by the Buffalo Forge Company, of Buffalo, N. Y., for use in chemical and electrochemical works. Since they are used for removing acid and other chemical fumes, they require an interior construction impervious to the action of the gases handled.

Fig. 1 illustrates a special type of exhauster designed for use under moderate pressure. This exhauster was originally designed and constructed under patent 602,770 for exhausting
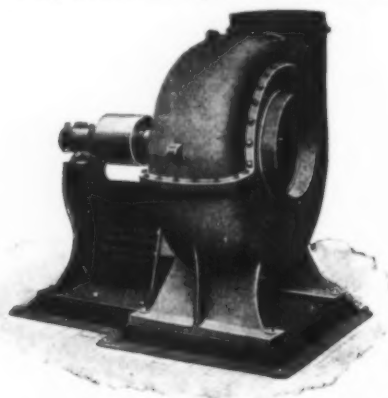

FIG. 1.—STEEL-PLATE FAN COATED WITH LEAD

acid fumes of a character very injurious to the regular steel plate or cast iron fan or exhauster. This apparatus is cast of an alloy made up of antimony and lead, no steel or iron being used in the construction. Exhausters of this type are of great service in chemical and electrochemical plants, fertilizer works, etc. The construction is such that easy excess may be had to the blast wheel.

Fig. 2 shows another special type of exhauster, suitable for use along the same line. It is of steel plate construction, but

FIG. 2.—EXHAUSTER, SHOWING SHEET-LEAD LINING.

designed for a sheet lead coating, which metal is not affected to any extent by the action of acid fumes. In many cases, the blast wheel is made entirely of an alloy cast of a spider frame. These exhausters can handle without injury fumes which attack steel and cast iron.

This type of exhauster may also be lined with sheets of pure copper and the blast wheel is often constructed of the same material. Where it is found absolutely necessary, exhausters built with steel plate shells may be lined with a heavy coat of glass.

For charcoal, coke, wood alcohol, acids, etc., the Buffalo

Forge Company build fans with cast iron shells and copper wheels, or in the larger sizes built of copper and brass throughout. Special fans of different construction are made to order; for instance, fans built entirely of aluminium are used for handling nitric acid fumes, and for certain sulphuric acid processes fans are of heavy cast iron throughout; in other cases composed of a mixture of lead and antimony.

Extensive developments have recently been made in the use of the waste gases from blast furnaces for power purposes. When used in gas engines, these gases will develop from five to six times as much power as when burned in the boilers. This opens a tremendous field for power development, and even bids fair to make the blast furnace as important as a producer of power as it is now as a producer of pig iron. One main obstacle which has hitherto prevented such a use of the blast furnace gases in gas engines, was the fact that they contain dust which rapidly destroys the surfaces of cylinders and pistons. To eliminate this dust the Buffalo Forge Company have developed huge gas-cleaning fans, and at the present time have batteries of fans in operation at a single steel plant which serves a total of 26,000 hp. of gas engines.

The special applications of fans for electrochemical industries are very common, as a visit through the works in all the electrochemical concerns at Niagara Falls will demonstrate.

ELECTRICALLY OPERATED STEAM OR AIR WHISTLE.

The problem of successfully operating a whistle for signal or other purposes by electricity has been developed by the Electrical Appliance Company of Cincinnati, Ohio. The adjoining illustration shows the standard type for all ordinary pressures of steam. This device operates any whistle up to
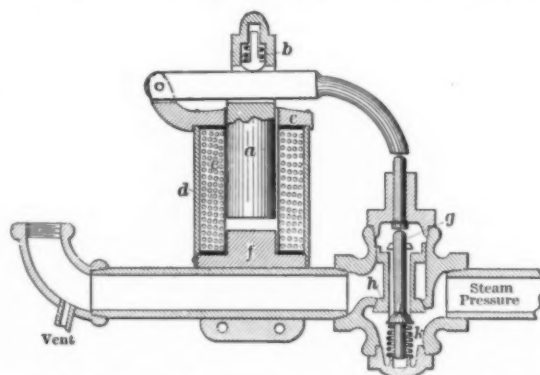
ELECTRICALLY OPERATED STEAM WHISTLE.

three inches diameter at 150 pounds steam pressure and when provided with a larger valve will operate a six-inch whistle at the same pressure. It may be placed either indoors or out, and at any required distance from the operating key.

In the illustration, a is an iron plunger, b a spring to raise this plunger above lever, c a magnet winding, d an iron shell, e the iron cap of the magnet, f the iron base of the magnet, g expansion chamber, h large valve seat, i small valve seat, and k spring to close the valves.

A special feature of this device is the fact that it may be operated either by direct or alternating current. Since the actuating solenoid must evidently be operated with direct current, it is necessary to convert the alternating current of the supply circuit into direct current for actuating the solenoid. This is acomplished by means of the Churcher electrolytic rectifier which was described on page 76 of our February issue.

The electrically-operated whistle should be useful in many large plants, such as steel mills, ship yards, lumber yards, etc., while various local uses will readily suggest themselves to steam engineers.

INDUSTRIAL NOTES

GOLD REFINING.—With reference to the articles of Dr. E. Wohlwill on gold refining published in our June and July issues, we are informed that Dr. Franz Meyer, 52 Broadway, New York City, is the representative of Dr. Wohlwill for his gold refining process in the United States and Canada.

INSTRUMENTS AND APPARATUS FOR LABORATORIES AND SCHOOLS.—We have received from the *Laboratory and School Supply Co.*, 20 to 24 East Twentieth Street, New York City, a pamphlet on "Kryptol," a new heating substance for electric furnaces. It is a granulated resistance material which takes the place of the heating wire in electric heating apparatus. It is either filled into the heating apparatus or spread out on clay or enamel plates. According to the thickness of the layer of kryptol and intensity of the current, the temperature can be changed at will, so that it is possible to produce different temperatures at different points of the same surface. The pamphlet describes various electric furnaces and heating apparatus adapted for the use of Kryptol. The same company have sent us a list of the very numerous apparatus exhibited by them at the World's Fair in St. Louis. They are to be found in the exhibit of the German Government in the Electricity Building (educational laboratory), Palace of Agriculture (chemical laboratory for an agricultural experiment station, and in the German Food Exhibition). Those apparatus which are of special interest to our readers will be described in one of our next issues in connection with the Exposition reports.

THE INTERNATIONAL ACHESON GRAPHITE COMPANY, of Niagara Falls, have broken ground for their new addition to their plant. The new buildings will measure 100 feet by 155 feet and will be constructed of steel. In this way the present capacity of the works will be doubled. Across Buffalo Avenue there is being erected a two-story office building to be occupied by the Acheson Graphite Co. and the Siloxicon Brick Co., which latter company will also shortly erect a factory.

Messrs. GEO. G. BLACKWELL, SONS & Co., Ltd., Liverpool, England, have sent us a copy of a new edition of their pamphlet on specialties for basic steel furnaces and refractory linings for steel, copper, lead, cement, electrical, oil, gas and smelting furnaces. The pamphlet gives interesting notes on fluorspar, ferro-phosphorous, magnesite, bricks, chrome firebricks and bauxite bricks.

WESTON INSTRUMENT PATENT LITIGATION.—Another decision has recently been rendered in the litigation on the Weston patents for electric measuring instruments. The suit was brought against the Whitney Electrical Instrument Co., on a patent issued to Edward Weston, dated November 6, 1888 (No. 392,387), and the decision was that the patent is infringed by an instrument made by the defendant. The court states that the parts of the defendant's instrument look quite different from the corresponding parts of the patent in suit, but notwithstanding these differences in form they are there in the instrument and do the same things in substantially the same way. The great thing to be done appears to have been to get the movable coil in its diamagnetic frame into a permanent magnetic field, compactly, and to carry the current to be measured from side to side through the coil, and move the coil against steady resistance to measure the current and record the measurement. The defendant's instruments have the permanent magnetic field provided by a magnet and a core of different and perhaps better shapes in some respects, but permitting movement of the frame in an arc of a circle to carry a pointer moving over a scale to indicate the measurement of the current. If these changes of form are even patentable improvements, the defendants have taken and used the invention of the patent in making and using their improvements. It was held that the differences do, not, any or all of them, amount to doing the same thing in different ways, but leave operative parts doing the same things in the same way. A motion for a preliminary

injunction was granted. The opinion is endorsed by Judge Lacombe as follows: "Upon re-examination of the record I concur in the opinion above expressed by Judge Wheeler."

The PERTH AMBOY CHEMICAL WORKS, of Perth Amboy, N. J., have issued a pamphlet on the use of formaldehyde as a disinfectant, deodorizer, insecticide, antiseptic, preservative, in breweries and tanneries, in photography, in paint and glue shops, in the paper industry, in agriculture, therapeutics, etc. The pamphlet is concluded by a description of a convenient method of analyzing formaldehyde.

Messrs. ARCHIBALD CONSTABLE & Co., LTD., of 2 Whitehall Gardens, S. W. London, announce the removal of their offices to 16 James Street, Haymarket, London.

TANGENTIAL WATER WHEELS.—The Abner Doble Co., of San Francisco, Cal., have sent us a neatly illustrated pamphlet on various details of construction of tangential water-wheels to operate under high heads of water. This company has made a specialty of producing large units of high economy, close regulation and absolute reliability in service.

We have received from the DEUTSCHE STEINZEUGWAAREN FABRIK for canalization and chemical industries in Friedrichsfeld, Baden, a neat pamphlet containing a description of the development and equipment of their works and output. The New York representative of this company is Frederick Bertuch & Co., 5 Beekman Street. The pamphlet was distributed on the occasion of a recent visit of the Society of German Chemists to the works. The plant now employs 700 workingmen.

PERSONAL.

Dr. J. W. RICHARDS, of Lehigh University, sailed on July 6, on the steamer "United States" of the Scandinavian-American line to spend two months on the coast of Norway.

Mr. CARL HAMBUECHEN, who is well known to the electrochemical fraternity by the excellent work which he has done as Prof. Burgess' coworker at the University of Wisconsin, is now connected with the Pittsburgh Reduction Co., at East St. Louis, Ill.

Dr. SCHUYLER SKAATS WHEELER, president of Crocker-Wheeler Company, sailed on July 13, with Mrs. Wheeler, on the White Star Liner "Baltic." On the pier, he said that he had planned a coaching trip in England; but early this spring Dr. Wheeler went on an automobile tour through the South of France and returned with the American patent rights of Brown, Boveri & Cie., of Baden, Switzerland. Dr. Wheeler's friends and rivals are beginning to take a lively interest in his holiday trips.

THE UNIVERSITY OF WISCONSIN, at its recent jubilee celebration, conferred the degree of LL. D. to Prof. Edgar F. Smith, of the University of Pennsylvania. President Van Hise addressed him as follows: "Edgar Fahs Smith—for pioneer work in the electrolytic separation of metals; for valuable researches upon the compounds of tungsten, molybdenum and uranium; for the training of a large number of scholars devoted to the advancement of the science of chemistry, this university confers upon you the degree of doctor of laws."

DIGEST OF U. S. PATENTS

PRIOR TO JULY, 1902.

Compiled by Byrnes & Townsend,

Patent Lawyers,

National Union Building, Washington, D. C.

PRODUCTION OF SODIUM FROM MOLTEN ELECTROLYTES.

(Continued from page 296.)

464,097, December 1, 1891, Ludwig Grabau, Hanover, Germany.

Lowers the melting point of a sodium chloride bath, to

prevent recombinations, by employing a mixture of potassium and sodium chlorides in equi-molecular proportions, and a chloride of an alkaline earth metal, preferably strontium, in the proportion of one molecule to three molecules of the alkali metal chlorides. The fusion temperature is thus lowered from a bright to a dull red.

The product contains 3 per cent of potassium, which may be removed from the sodium by melting the alloy under petroleum and injecting sufficient air to oxidize the potassium.

517,001, March 20, 1894, J. D. Darling, Philadelphia, Pa.

Electrolyzes fused alkali metal nitrates, the first sodium reducing the nitrate at the cathode to nitrate and oxide, which dissolves in the nitrite. The nitrate is fused before electrolyzing and may be heated to a high temperature to drive off as much oxygen as possible to prevent attack on the anode. Employs a cathode vessel of aluminium, with a partition of aluminium extending nearly to its bottom. The anodes are of carbon or platinum, each surrounded by a sleeve of aluminium having inwardly and upwardly extending perforations to retain the anions, nitrogen dioxide and oxygen, which are conducted through Woulff bottles holding water, to produce nitric acid. May maintain a partial vacuum in the bottles and thus dispense with the aluminium sleeves. A feed hopper extends into the cell, being sealed at the bottom by the electrolyte.

531,235, December 18, 1894, C. T. J. Vautin, London, England.

Electrolyzes sodium or potassium carbonates or chlorides, to which may be added calcium or strontium chloride to lower the melting point. The vessel may be the hearth of a reverberatory furnace. The cathode is molten lead, beneath the electrolyte. Carbon anodes, surrounded by fire-clay sleeves to withdraw the chlorine, extend through the furnace roof. A horizontal passage extending from the bottom of the hearth opens into the bottom of an oxidizing vessel, wherein a jet of steam is thrown upon the alloy, converting the alkali metal into caustic, which may be ladled or tapped off. Fresh quantities of the alkali metal continuously diffuse from the cathode into the oxidizing vessel, as removed by the steam.

According to a modification, a lined crucible serves as the cell.

541,465, June 25, 1895, C. T. J. Vautin, London, England.

Electrolyzes alkali or alkaline earth metal chlorides on a cathode of molten lead or tin. The vessel may be an iron crucible, the sides of which are lined with magnesia, or the hearth of a reverberatory furnace. An outlet pipe for the alloy leads from the cell and is surrounded by a coil of pipe carrying water. A portion of the alloy is thus chilled in the outlet to constitute a plug, which melts out when the flow of water is stopped. The alloy may be cast into blocks by running it through a jet of reducing gas into a mold; or it may be discharged into a retort lined with magnesia or carbon and the alkali metal distilled off and condensed, the heating means being a carbon resistance rod in a tube passing horizontally through the retort.

542,057, July 2, 1895, L. P. Hulin, Modane, France.

Electrolyzes molten haloids of alkali or alkaline earth metals, on a cathode of molten lead or tin. The vessel is of iron, the sides having an insulating lining. There are four anodes: one of carbon; two of iron in shunt with a resistance and ammeter, purpose not stated; and a fourth of an alloying metal which may be the same metal as the cathode, in shunt with another resistance and ammeter. This metal of the fourth anode, if molten at the temperature of the cell, may be held in a carbon pan carried by a tubular carbon stem serving as a feed inlet. Less fusible metals, such as manganese and chromium, may be held in a carbon pan in granu-

lar form; or pieces containing their oxides and carbon may be supported in a carbon pan; or a mixture of their oxides and carbon may be formed into a stick anode. The anode metal dissolves and is redeposited simultaneously with the light metal, the proportions being determined by the amount of current supplied to the various anodes, the deposit being mostly of light metal. The soluble metal anodes permit the use of a lower e. m. f. and may be supplied with current from a separate dynamo; or current may be fed to them intermittently. May produce alloys with two or more heavy metals, using a molten bath containing haloids of both metals, with anodes of each or an anode consisting of an alloy of both. A feed inlet for the salt opens into the cell below the surface of the electrolyte. The molten cathode is continuously agitated by an iron stirrer.

544,153, August 6, 1895, W. Borchers, Duisburg, Germany.

Electrolyzes molten sodium chloride in a conductive or non-conductive vessel having a conical bottom, the inner face of which consists of a series of horizontal, annular grooves. The grooves are filled with molten lead, constituting the cathode. Lead is continuously supplied to the top groove and the alloy is withdrawn from the bottom. The body of the vessel is surrounded by a water-jacket, which cools a lining of the solidified salt on the inner wall.

The anode is a piece of charcoal or metal extending through the vessel-cover.

589,523, September 7, 1897, J. Boelsterli, Neuhausen, Switzerland.

Electrolyzes alkali metal compounds in an iron crucible. The anode is a vertical ring, surrounded by an iron sheath to retain and carry off the oxygen. The cathodes are depending metal rods, arranged in a ring around the anode and adjustably supported by radial arms extending from a sleeve on the anode stem. The lower end of each rod is rounded and just dips below the surface of the electrolyte. These ends gather the globules of metal that float on the surface, and they are then removed by a skimmer. The skimmings are placed in a separating vessel to permit any portions of the electrolyte therein to settle out.

590,826, September 28, 1897, J. D. Darling, Philadelphia, Pa.

Electrolyzes molten alkali or alkaline earth metal hydroxides, haloids, nitrates or sulphates, in a diaphragm cell. The diaphragm consists of concentric cylindrical cups of perforated sheet iron, with an intermediate space which is filled with vitrified magnesia, in fragments which will pass through a 20-mesh, but not through a 30-mesh sieve. A ring of cement is filled in at the top.

Other earthy oxides or mixtures, e. g., of calcium or barium, may be used.

607,506, July 19, 1898, Paul Danckwardt, New York, N. Y.

Electrolyzes molten alkali metal chlorides. The cell is a rectangular chamber with anode and cathode compartments partially separated by a depending water-cooled partition. The walls of the anode compartment consist of water-jackets lined with tile; those of the cathode compartment, of fire-brick with a sheet iron lining serving as cathode. Several parallel iron strips extend from the bottom of the iron lining into the upper hotter portion of the electrolyte, to prevent it from cooling on the bottom. The bottom of the cell is of fire-brick, with embedded water pipes to cool it. The anode compartment has a cover with inlet and gas outlet. Carbon anodes extend through one side of the anode compartment and nearly to the cathode compartment. Heat is supplied by a blow-pipe passing through one end of the anode compartment, above the electrolyte; or a layer of charcoal may be supported on the anolyte and burned by an air-blast. The alkali metal floats and is continuously run off from the cathode

(*To be continued.*)